


PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 11399/EG	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/US00/16323	International filing date (day/month/year) 12/07/2000	Priority date (day/month/year) 16/07/1999
International Patent Classification (IPC) or national classification and IPC A61K31/00		
Applicant G.D. SEARLE & CO. et al.		
<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 9 sheets, including this cover sheet.</p> <p><input type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of sheets.</p>		
<p>3. This report contains indications relating to the following items:</p> <ul style="list-style-type: none">I <input checked="" type="checkbox"/> Basis of the reportII <input type="checkbox"/> PriorityIII <input checked="" type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicabilityIV <input type="checkbox"/> Lack of unity of inventionV <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statementVI <input checked="" type="checkbox"/> Certain documents citedVII <input type="checkbox"/> Certain defects in the international applicationVIII <input checked="" type="checkbox"/> Certain observations on the international application		
Date of submission of the demand 30/01/2001	Date of completion of this report 02.11.2001	
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Tardi, C Telephone No. +49 89 2399 8180	



INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/US00/16323

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17):*)

Description, pages:

1-63 as originally filed

Claims, No.:

1-64 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

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(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

☐ the entire international application.

☒ claims Nos. 37, 57, 59-64.

because:

☒ the said international application, or the said claims Nos. 59-64, regarding industrial applicability relate to the following subject matter which does not require an international preliminary examination (*specify*):
see separate sheet

☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. 37, 57 are so unclear that no meaningful opinion could be formed (*specify*):
see separate sheet

☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.

☐ no international search report has been established for the said claims Nos. .

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

☐ the written form has not been furnished or does not comply with the standard.

☐ the computer readable form has not been furnished or does not comply with the standard.

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	10, 14-15, 18, 32, 35, 52, 55, 61, 64
	No:	Claims	1-9, 11-13, 16-17, 19-31, 33-34, 36, 38-51, 53-54, 56, 58-60, 62-63
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-36, 38-56, 58-64
Industrial applicability (IA)	Yes:	Claims	1-18

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No: Claims 19-58

2. Citations and explanations
see separate sheet

VI. Certain documents cited

1. Certain published documents (Rule 70.10)

and / or

2. Non-written disclosures (Rule 70.9)

see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

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Re Item III

- 1) As the figures 1-16 are not present in the file, it does not appear possible to formulate an opinion on the claims 37 and 57 regarding N and IS.
- 2) Claims 59-64 relate to subject-matter considered by this Authority to be covered by the provisions of Rule 67.1(iv) PCT. Consequently, no opinion will be formulated with respect to the industrial applicability of the subject-matter of these claims (Article 34(4)(a)(i) PCT).

Re Item V

- 1) Reference is made to the following documents:
D1: WO 98 39329 A (ABBAS S Z ; MCDONALD J J ; MONSANTO CO (US); GETMAN D) 11 September 1998
D2: TAMURA Y ET AL: 'HIGHLY SELECTIVE AND ORALLY ACTIVE INHIBITORS OF TYPE IV COLLAGENASE (MMP-9 AND MMP-2): N-SULFONYLAMINO ACID DERIVATIVES' J. OF MEDICINAL CHEM., AM. CHEM. SOCIETY. WASHINGTON, US, 41(4), 1998, p.640-649.
D3: EP-A-0 757 037 (ONO PHARMACEUTICAL CO) 5 February 1997
D4: EP-A-0 757 984 (ONO PHARMACEUTICAL CO) 12 February 1997
D5: JP 11 236369 A (KOTOBUKI SEIYAKU KK) 31 August 1999
- 2) Novelty (Art. 33(2) PCT)

Not novel

2.1 Claims 1-9, 11-13, 16-17

The document D1 discloses in the Tables 1, 5 and 8 and in the examples 1, 2, 4, 4a, 7-12 and 14-15 compounds as MMP inhibitors which fall within claims 1-6, 11, 12, 16, 17. In particular, the example 9 p.180 and example 10 p.182 disclose the compounds X and XI (claims 16 and 17) of the present application respectively. Therefore the subject-matter of claims 1-6, 11, 12, 16, 17 is not new.

The document D2 discloses in the Table 4 compounds as MMP inhibitors which

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fall within claims 1-9. Therefore, the subject-matter of these claims is not new.

The document D3 discloses on p.4 I.1-13, in Table 1, p.39 I.1, 13, 19-24 and 51, and in the examples 2, 2(3), 2(4), 2(8), 2(9), 2(10), 2(12), 2(16), 2(17), 2(34), 2(35), 2(37), 2(45), 2(46), 2(49)-2(53), 2(57), 2(62)-2(68), 2(71)-2(74), 3(7), 3(9), 3(11)-3(13), compounds as MMP inhibitors which fall within claims 1-9. Therefore, the subject-matter of these claims is not new.

The document D4 discloses in Table 1, in the reference examples 4-4(4) and in the examples 2-2(4) compounds as MMP inhibitors which fall within claims 1-9 and 11-13. Therefore, the subject-matter of these claims is not new.

The document D5 discloses on the bottom of p.15 and in the middle of p.16 compounds as MMP inhibitors which fall within claims 1-4, 7, 11. Therefore, the subject-matter of these claims is not new.

2.2 Claims 19-31, 33-34, 39-51, 53-54

These claims refer to a method of changing the conformation of a matrix metalloproteinase, by contacting the MMP with a compound of a formula as disclosed in claims 1-9, 11-13, 16-17. Therefore, the subject-matter of these claims is not new (see paragraph 2.1).

2.3 Claims 36, 38, 56 and 58

The document D1 discloses that its claimed MMP inhibitors are particularly selective for the MMP-13 (p.22 I.29 to p.23 I.20).

Therefore, the subject-matter of claims 36, 38, 56 and 58 is not novel.

2.4 Claims 59, 60, 62 and 63

These claims refer to a method of treating osteoarthritis in a mammal by administering a compound as defined in claim 1 (claim 59), claim 16 (claim 62) and claim 17 (claim 63).

Compounds as defined in claim 1 are already known as MMP inhibitors (see paragraph 2.1), D1 precises that this make them useful for the treatment of diseases and disorders including osteoarthritis (p.8 I.1-10). Therefore, the subject-matter of claims 59, 60, 62 and 63 is not new.

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Novel

2.5 Claims 10, 14-15, 18, 32, 35, 52, 55, 61, 64

The subject-matter of these claims has not been explicitly disclosed in the prior art and therefore appears to be novel.

3) Inventive step (Art. 33(3) PCT)

3.1 Claim 10

The document D3 is regarded as being the closest prior art to the subject-matter of claim 10, and discloses in Table 1 p.16 compounds falling within claim 9, where the heterocycloalkyl in the position R³ is phenylethyl (compounds 6 and 8) or indolyethyl (compound 7). The subject-matter of claim 10 therefore differs from these known compounds in that the heterocycloalkyl in the position R³ is 2-(N-morpholino)ethyl.

The substituent in the position R³ is defined in D3 among others as a C1-4 alkyl substituted by a heterocyclic ring (p.7, I.39-40), and the definition of heterocyclic ring includes morpholine (p.9 I.42-50).

In the absence of any unexpected effect, a 2-(N-morpholino)ethyl in the position R³ thus only appears to be one of several alternatives a skilled person could have chosen taking into account the teaching of D3.

Therefore, the subject-matter of claim 10 does not appear to involve any inventive step.

3.2 Claim 14

The document D4 is regarded as being the closest prior art to the subject-matter of claim 14, and discloses in Table 1 p.11 compounds falling within claim 13, where the heterocycloalkyl in the position R³ is phenylethyl (compounds 6 and 8) or indolyethyl (compound 7). The subject-matter of claim 14 therefore differs from these known compounds in that the heterocycloalkyl in the position R³ is 2-(N-morpholino)ethyl.

The substituent in the position R³ is defined in D4 among others as a C1-4 alkyl substituted by a heterocyclic ring (p.4, I.53-54), and the definition of heterocyclic ring includes morpholine (p.5 I.39-47).

In the absence of any unexpected effect, a 2-(N-morpholino)ethyl in the position R³ thus only appears to be one of several alternatives a skilled person could have

chosen taking into account the teaching of D4.

Therefore, the subject-matter of claim 14 does not appear to involve any inventive step.

3.3 Claims 15, 32, 52, 61

The document D1 is regarded as being the closest prior art to the subject-matter of claim 15, and discloses the compound R-N-[4-[[[1-(hydroxyamino)carbonyl]-2-methylpropyl] [2-(4-orpholiny)ethyl]amino]-sulfonyl]phenyl]-4-pentylbenzamide, hydrochloride (p.179-180, Example 9), from which the subject-matter of claim 15 differs in that the substituent in position R²⁰ is -COOH instead of -C(O)NHOH. As these two compounds are structurally close and exhibit the same physiological activity (MMP inhibitors), and in the absence of any unexpected effect, the subject-matter of claim 15 does not appear to involve any inventive step.

Consequently the claims 32, 52 and 61 relating to methods using this compound do not appear to involve an inventive step either.

3.4 Claims 18, 35, 55, 64

The document D3 is regarded as being the closest prior art to the subject-matter of claim 18, and discloses in the example 2(64) p.101-102 the compound N-[[4-(p-toluoylamino)phenyl]sulfonyl]-L-valine, from which the subject-matter of claim 18 differs in that the substituent in position R²³ is propyl instead of methyl. The substituent in the position R²³ is defined in D3 among others as a C1-15 alkyl, which includes methyl, ethyl, propyl, etc...(p.9 l.20).

In the absence of any unexpected effect, a propyl in the position R²³ thus only appears to be one of several alternatives a skilled person could have chosen taking into account the teaching of D3.

Therefore, the subject-matter of claim 18 does not appear to involve any inventive step.

Consequently the claims 35, 55 and 64 relating to methods using this compound do not appear to involve an inventive step either.

- 4) 4.1 The subject-matter of claims 1-18 fulfills the requirements of Art. 33(4) PCT regarding industrial applicability.

4.2 The subject-matter of claims 19-58 relates to a method of changing the

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conformation of a matrix metalloproteinase, i.e. it relates to a biochemical reaction. This is in itself not industrially applicable.

4.3 For the assessment of the present claims 59-64 on the question whether they are industrially applicable, no unified criteria exist in the PCT Contracting States. The patentability can also be dependent upon the formulation of the claims. The EPO, for example, does not recognize as industrially applicable the subject-matter of claims to the use of a compound in medical treatment, but may allow, however, claims to a known compound for first use in medical treatment and the use of such a compound for the manufacture of a medicament for a new medical treatment.

Re Item VI

Certain published documents (Rule 70.10)

Application No Patent No	Publication date (day/month/year)	Filing date (day/month/year)	Priority date (valid claim) (day/month/year)
WO 99 42433	26 August 1999	18 September 1998	
EP-A-0 950 656	20 October 1999	22 January 1997	
and: PATENT ABSTRACTS OF JAPAN vol. 1999, no. 14, 22 December 1999 & JP 11 246527 A (SHIONOGI & AMP;CO LTD), 14 September 1999.			

Although these documents do not belong to the state of the art in the sense of Rule 64.1(b) PCT, they might disclose all the features of claims 1-64.

Re Item VIII

1) Art. 6 PCT (lack of clarity)

1.1 Claims 15 and 18 appear to be wrongly appended to claim 14 because they bear a -COOH group in the position R²⁰ and not a -C(O)NHOH group as defined in claim 14.

1.2 Claims 15-18 are unclear because they bear the (N-morpholino)ethyl group in the position R² and not in the position R³ as defined in claim 14 to which they are appended.

PATENT COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner
 US Department of Commerce
 United States Patent and Trademark
 Office, PCT
 2011 South Clark Place Room
 CP2/5C24
 Arlington, VA 22202
 ETATS-UNIS D'AMERIQUE
 in its capacity as elected Office

Date of mailing (day/month/year) 21 March 2001 (21.03.01)	Applicant's or agent's file reference 3333/PCT
International application No. PCT/US00/16323	
International filing date (day/month/year) 12 July 2000 (12.07.00)	Priority date (day/month/year) 16 July 1999 (16.07.99)
Applicant STALLINGS, William, C. et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:
 30 January 2001 (30.01.01)

☐ in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was
☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer F. Baechler Telephone No.: (41-22) 338.83.38
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INTERNATIONAL COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 3333/PCT	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/US 00/ 16323	International filing date (day/month/year) 12/07/2000	(Earliest) Priority Date (day/month/year) 16/07/1999
Applicant G.D. SEARLE & CO. et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 4 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☐ the text is approved as submitted by the applicant.

☒ the text has been established by this Authority to read as follows:

N-SULFONYLAMINIACID DERIVATIVES AS INHIBITORS OF METALLOPRTEINASE

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

1
☐ None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No

US 00/16323

A. CLASSIFICATION OF SUBJECT MATTER IPC 7 A61K31/5375 A61K31/63 A61P29/00		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC 7 A61K		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, BIOSIS		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98 39329 A (ABBAS S ZAHEER;MCDONALD JOSEPH J ; MONSANTO CO (US); GETMAN DANIEL) 11 September 1998 (1998-09-11) page 8, line 7-9; claims examples <div style="text-align: center;">---</div>	1-64
X	TAMURA Y ET AL: "HIGHLY SELECTIVE AND ORALLY ACTIVE INHIBITORS OF TYPE IV COLLAGENASE (MMP-9 AND MMP-2): N-SULFONYLAMINO ACID DERIVATIVES" JOURNAL OF MEDICINAL CHEMISTRY, AMERICAN CHEMICAL SOCIETY. WASHINGTON, US, vol. 41, no. 4, 1998, pages 640-649, XP002072052 ISSN: 0022-2623 table 4 <div style="text-align: center;"> <div style="display: flex; justify-content: space-around; align-items: center;"> <div>---</div> <div>---/---</div> </div> </div>	1-7, 19-21, 25,27, 28, 39-41, 45, 47-50, 56-60
<div style="display: flex; justify-content: space-between;"> <div> <input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. </div> <div> <input checked="" type="checkbox"/> Patent family members are listed in annex. </div> </div>		
<div style="display: flex;"> <div style="flex: 1;"> <p>* Special categories of cited documents :</p> <p>*A* document defining the general state of the art which is not considered to be of particular relevance</p> <p>*E* earlier document but published on or after the international filing date</p> <p>*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>*O* document referring to an oral disclosure, use, exhibition or other means</p> <p>*P* document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="flex: 1;"> <p>*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>*G* document member of the same patent family</p> </div> </div>		
Date of the actual completion of the international search <div style="text-align: center; font-weight: bold;">7 February 2001</div>		Date of mailing of the international search report <div style="text-align: center; font-weight: bold;">22/02/2001</div>
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016		Authorized officer <div style="text-align: center; font-weight: bold;">Veronese, A</div>

INTERNATIONAL SEARCH REPORT

International Application No.

US 00/16323

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 757 037 A (ONO PHARMACEUTICAL CO) 5 February 1997 (1997-02-05) claims; tables 1,20,21,23 ---	1-9, 19-23, 25, 27-31, 39-41, 45, 47-50, 56-60
X	EP 0 757 984 A (ONO PHARMACEUTICAL CO) 12 February 1997 (1997-02-12) tables 1,20,21.23 ---	1-6,8,9, 19-23, 25, 27-31, 39-41, 45, 47-50, 56-60
X	JP 11 236369 A (KOTOBUKI SEIYAKU KK) 31 August 1999 (1999-08-31) claims; examples ---	1-7, 19-21, 39-41, 47-50
P,X	WO 99 42433 A (KIM YOUNG GYU ;CHUNG KYOO HYUN (KR); LEE BON SU (KR); LEE YOON SIK) 26 August 1999 (1999-08-26) examples 12,25 ---	1-4,8,9, 11-13, 19,21, 25,27, 28, 39-41, 45, 47-50, 56-60
A	WO 98 03166 A (MCDONALD JOSEPH J ;MONSANTO CO (US); ABBAS ZAHEER S (US); FRESKOS) 29 January 1998 (1998-01-29) page 269; claims; tables 4,28,71,72 ---	1,36,38, 56,58
P,X	PATENT ABSTRACTS OF JAPAN vol. 1999, no. 14, 22 December 1999 (1999-12-22) & JP 11 246527 A (SHIONOGI &CO LTD), 14 September 1999 (1999-09-14) abstract --- -/--	1-4,19, 36,37, 56,57

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International Application No

US 00/16323

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, X	EP 0 950 656 A (SHIONOGI & CO) 20 October 1999 (1999-10-20) claims; tables	1-7, 19-21, 25, 27, 28, 39-41, 45, 47-50, 56-60
A	KIYAMA RYUICHI ET AL: "Homology modeling of gelatinase catalytic domains and docking simulations of novel sulfonamide inhibitors." JOURNAL OF MEDICINAL CHEMISTRY, vol. 42, no. 10, 20 May 1999 (1999-05-20), pages 1723-1738, XP002159721 ISSN: 0022-2623 the whole document	1-63

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 00/16323

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9839329	A	11-09-1998	AU 6542398 A EP 0983267 A EP 0977745 A	22-09-1998 08-03-2000 09-02-2000
EP 0757037	A	05-02-1997	JP 9309875 A	02-12-1997
EP 0757984	A	12-02-1997	JP 9104672 A KR 231230 B US 6022893 A	22-04-1997 15-11-1999 08-02-2000
JP 11236369	A	31-08-1999	NONE	
WO 9942433	A	26-08-1999	EP 1062198 A	27-12-2000
WO 9803166	A	29-01-1998	AU 3890397 A BR 9710752 A CN 1238688 A CZ 9900168 A EP 0939629 A JP 2000515153 T NO 990247 A PL 331338 A	10-02-1998 17-08-1999 15-12-1999 11-08-1999 08-09-1999 14-11-2000 19-03-1999 05-07-1999
JP 11246527	A	14-09-1999	NONE	
EP 0950656	A	20-10-1999	AU 715764 B AU 1319597 A BR 9707010 A HU 9903687 A NO 983376 A SK 98498 A US 6150394 A CA 2242416 A CN 1214041 A CZ 9802252 A WO 9727174 A PL 328270 A	10-02-2000 20-08-1997 20-07-1999 28-03-2000 14-09-1998 13-04-1999 21-11-2000 31-07-1997 14-04-1999 16-12-1998 31-07-1997 18-01-1999

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International Application No
PCT/US 00/16323

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61K31/5375 A61K31/63 A61P29/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, BIOSIS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98 39329 A (ABBAS S ZAHEER;MCDONALD JOSEPH J ; MONSANTO CO (US); GETMAN DANIEL) 11 September 1998 (1998-09-11) page 8, line 7-9; claims examples	1-64
X	TAMURA Y ET AL: "HIGHLY SELECTIVE AND ORALLY ACTIVE INHIBITORS OF TYPE IV COLLAGENASE (MMP-9 AND MMP-2): N-SULFONYLAMINO ACID DERIVATIVES" JOURNAL OF MEDICINAL CHEMISTRY, AMERICAN CHEMICAL SOCIETY, WASHINGTON, US, vol. 41, no. 4, 1998, pages 640-649, XP002072052 ISSN: 0022-2623 table 4	1-7, 19-21, 25,27, 28, 39-41, 45, 47-50, 56-60

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

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Veronese, A

INTERNATIONAL SEARCH REPORT

International Application No
P S 00/16323

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, X	EP 0 950 656 A (SHIONOGI & CO) 20 October 1999 (1999-10-20)	1-7, 19-21, 25,27, 28, 39-41, 45, 47-50, 56-60
A	claims; tables KIIYAMA RYUICHI ET AL: "Homology modeling of gelatinase catalytic domains and docking simulations of novel sulfonamide inhibitors." JOURNAL OF MEDICINAL CHEMISTRY, vol. 42, no. 10, 20 May 1999 (1999-05-20), pages 1723-1738, XP002159721 ISSN: 0022-2623 the whole document	1-63

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/JP 00/16323

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EP 0757037 A	05-02-1997	JP 9309875 A	02-12-1997
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JP 11246527 A	14-09-1999	NONE	
EP 0950656 A	20-10-1999	AU 715764 B AU 1319597 A BR 9707010 A HU 9903687 A NO 983376 A SK 98498 A US 6150394 A CA 2242416 A CN 1214041 A CZ 9802252 A WO 9727174 A PL 328270 A	10-02-2000 20-08-1997 20-07-1999 28-03-2000 14-09-1998 13-04-1999 21-11-2000 31-07-1997 14-04-1999 16-12-1998 31-07-1997 18-01-1999

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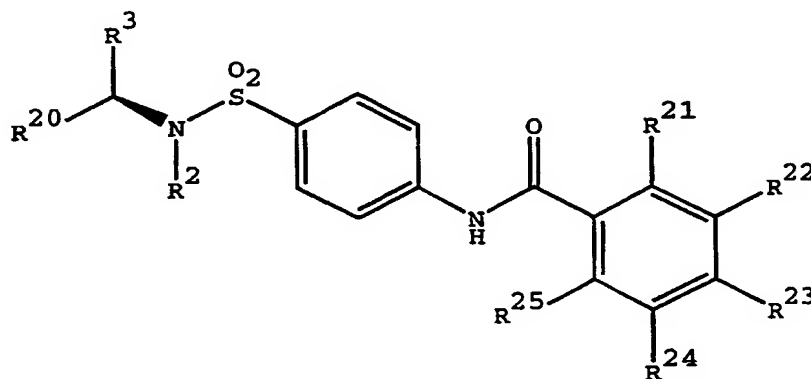
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60/144,133 **16 July 1999 (16.07.1999)** **US**
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(54) Title: **METHOD OF CHANGING CONFORMATION OF A MATRIX METALLOPROTEINASE**



(VIII)

(57) Abstract: The present invention provides a matrix metalloproteinase inhibiting compound having structure (VIII) or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof. In other embodiments, the present invention provides a method of changing the conformation of a matrix metalloproteinase, a method of inhibiting a matrix metalloproteinase, and a method of treating osteoarthritis.

WO 01/05389 A2

**Method of Changing Conformation
of a Matrix Metalloproteinase**

5

BACKGROUND OF THE INVENTION

This application claims priority of U.S.
Provisional Patent Application Serial No. 60/144,133,
filed July 16, 1999

10

Field of the Invention

This invention relates to matrix metalloproteinase
enzymes, inhibitors of matrix metalloproteinase enzymes,
and to methods of changing the conformation of matrix
15 metalloproteinase enzymes.

Description of Related Art

Connective tissue, extracellular matrix
constituents, and basement membranes are required
20 components of all mammals, including humans. These
components are the biological materials that provide
rigidity, differentiation, attachments, and, in some
cases, elasticity to biological systems. Connective
tissue components include, for example, collagen,
25 elastin, proteoglycans, fibronectin, and laminin. These
biochemicals make up or are components of structures
such as skin, bone, teeth, tendons, cartilage, basement
membranes, blood vessels, cornea, and vitreous humor.

Under normal conditions, connective tissue turnover
30 or repair processes are controlled and in equilibrium.
The loss of this balance for whatever reason leads to a
number of disease states. Inhibition of the enzymes
responsible for loss of equilibrium provides a control
mechanism for this tissue decomposition and, therefore,
35 a treatment for these diseases.

Degradation of connective tissue or connective tissue components is carried out by the action of proteinase enzymes released from resident tissue cells or invading inflammatory or tumor cells. A major class of enzymes involved in this function includes the matrix metalloproteinase (MMP) enzymes. The MMPs are the subject of extensive study because of their potential involvement in disease mechanisms. Parks and Mecham have extensively reviewed the MMPs (Matrix Metalloproteinases, W.C. Parks and R.P. Mecham, ed., Academic Press, San Diego (1998)).

The MMPs are divided into classes with some members having several different names in common use. Examples are: collagenase I (MMP-1, fibroblast collagenase, EC 3.4.24.3); collagenase II (MMP-8, neutrophil collagenase, EC 3.4.24.34); collagenase III (MMP-13); stromelysin 1 (MMP-3, EC 3.4.24.17); stromelysin 2 (MMP-10, EC 3.4.24.22); proteoglycanase; matrilysin (MMP-7, EC 3.4.25.33); gelatinase A (MMP-2, 72 kDa gelatinase, EC 3.4.24.24); gelatinase B (MMP-9, 92 kDa gelatinase, EC 3.4.24.35); stromelysin 3 (MMP-11); metalloelastase (MMP-12, HME, human macrophage elastase, EC 3.4.24.65); MT1-MMP (MMP-14); MT2-MMP (MMP-15); MT3-MMP (MMP-16); and MT4-MMP (MMP-17).

The uncontrolled breakdown of connective tissue by MMPs is a feature of many pathological conditions. Examples include rheumatoid arthritis, osteoarthritis, septic arthritis, ulcerations (such as corneal, epidermal, or gastric ulcerations), periodontal disease, proteinuria; Alzheimer's Disease, coronary thrombosis, psoriasis, aneurysm, and bone disease. Defective injury repair processes also occur. This can produce improper wound healing leading to weak repairs, adhesions, and scarring. These latter defects can lead to disfigurement and/or permanent disabilities as with post-surgical adhesions.

MMP-8 (also known as neutrophil collagenase) has been shown to degrade type II collagen and aggrecan (a structural glycosaminoglycan found in the cartilage). MMP-8 has been found to be present in patients having
5 osteoarthritis and rheumatoid arthritis and may participate significantly in the progression of these diseases. Matrix Metalloproteinases, W.C. Parks and R.P. Mecham, ed., Academic Press, San Diego (1998), pp. 32-33.

10 MMPs are also involved in the biosynthesis of tumor necrosis factor (TNF). Inhibition of the production or action of TNF and related compounds is a useful clinical disease treatment mechanism. TNF- α , for example, is a cytokine that is believed to be produced initially as a
15 28 kDa cell-associated molecule. It is released as an active, 17 kDa form that can mediate many deleterious effects *in vitro* and *in vivo*. For example, TNF can cause or contribute to the effects of inflammation, rheumatoid arthritis, autoimmune disease, multiple
20 sclerosis, graft rejection, fibrotic disease, cancer, infectious diseases, malaria, mycobacterial infection, meningitis, fever, psoriasis, cardiovascular/pulmonary effects (such as post-ischemic reperfusion injury, congestive heart failure hemorrhage, coagulation, and
25 hyperoxic alveolar injury), radiation damage, and acute phase responses like those seen with infections and sepsis during shock such as septic shock and hemodynamic shock. Chronic disease of active TNF can cause cachexia and anorexia. Chronic release of TNF can be lethal.

30 TNF- α convertase is a metalloproteinase involved in the formation of active TNF- α . Inhibition of TNF- α convertase inhibits production of active TNF- α . Some compounds that inhibit TNF- α convertase and MMPs involved in TNF- α biosynthesis are disclosed in PCT
35 Patent Application No. WO 94/24140. Additional

compounds that inhibit such enzymes are disclosed in PCT Patent Application No. WO 94/02466. Further inhibitors are disclosed in PCT Patent Application No. WO 97/20824.

5 Some compounds that inhibit certain MMPs have been shown to also inhibit the release of TNF (Gearing et al., *Nature*, 376, 555-557 (1994)). McGeehan et al. disclosed further compounds which inhibit MMPs and inhibit the release of TNF (*Nature*, 376, 558-561 (1994)). There remains a need for effective MMP and TNF-
10 α convertase-inhibiting agents.

MMPs are involved in other biochemical processes as well. Included are the control of ovulation, post-partum uterine involution, possibly implantation of fertilized ova, cleavage of APP (β -Amyloid Precursor
15 Protein) to the amyloid plaque and inactivation of α_1 -protease inhibitor (α_1 -PI). Inhibition of these metalloproteinases permits, for example, the control of fertility and the treatment or prevention of Alzheimer's Disease. In addition, increasing and maintaining the
20 levels of an endogenous or administered serine protease inhibitor drug or biochemical such as α_1 -PI supports the treatment and prevention of diseases such as emphysema, pulmonary diseases, inflammatory diseases, and diseases of aging such as loss of skin or organ stretch and
25 resiliency.

Inhibition of selected MMPs can also be desirable in other instances. For example, selective inhibition of MMP-3, MMP-2, MMP-9, or MMP-13 in the presence of MMP-1 may be useful for the treatment of cancer,
30 prevention of metastasis of cancer cells, or the inhibition of angiogenesis. A therapy which does not inhibit MMP-1 but does selectively inhibit one or more of the other MMPs can have a therapeutically useful profile.

Osteoarthritis, another prevalent disease wherein it is believed that cartilage degradation in flamed joints is at least partially caused by MMP-13 released from cells such as stimulated chondrocytes, may be best
5 treated by administration of drugs which selectively inhibit MMP-13. See, for example, Mitchell et al., *J. Clin. Invest.*, 97, 761-768 (1996). See also Reboul et al., *J. Clin. Invest.*, 97, 2011-2019 (1996).

Some inhibitors of MMPs are known. Examples
10 include natural biochemicals such as tissue inhibitor of metalloproteinase (TIMP), α_2 -macroglobulin, and their analogs or derivatives. These are high molecular weight protein molecules that form inactive complexes with metalloproteinases.

15 Some smaller peptide-like compounds that inhibit MMPs have also been described. Thiol group-containing amide or peptidyl amide-based metalloproteinase (MMP) inhibitors are known as is shown in, for example, PCT Patent Application No. WO 95/12389. Further such
20 inhibitors are described in PCT Patent Application No. WO 97/24117. Still further such inhibitors are shown in U.S. Patent Application No. 4,595,700. Hydroxamate group-containing MMP inhibitors are disclosed in a number of individual patent applications such as each of
25 the following:

WO 95/29892.
WO 97/24117.
EP 0 780 386.
WO 90/05719.
30 WO 93/20047.
WO 95/09841.
WO 96/06074.

Swartz et al. disclose some peptidomimetic MMP inhibitors in *Progr. Med. Chem.*, 29, 271-334 (1992).
35 Further peptidomimetic MMP inhibitors are disclosed by Rasmussen et al., in *Pharmacol. Ther.*, 75(1), 69-75

(1997). Denis et al., disclose further peptidomimetic MMP inhibitors in *Invest. New Drugs*, 15(3), 175-185 (1997).

One possible problem associated with many known MMP inhibitors is that they often exhibit the same or similar inhibitory effects against each of the MMP enzymes. In other words, many known MMP inhibitors are not very selective. For example, the peptidomimetic hydroxamate known as batimastat is reported to exhibit IC₅₀ values of about 1 to about 20 nanomolar (nM) against each of MMP-1, MMP-2, MMP-3, MMP-7, and MMP-9. Marimastat, another peptidomimetic hydroxamate, was reported to be another broad-spectrum MMP inhibitor with an enzyme inhibitory spectrum similar to batimastat, except that marimastat exhibits an IC₅₀ value against MMP-3 of about 230 nM. (Rasmussen et al., *Pharmacol. Ther.*, 75(1), 69-75 (1997))

Meta analysis of data from Phase I/II studies using marimastat in patients with advanced, rapidly progressive, treatment-refractory solid tumor cancers (colorectal, pancreatic, ovarian, prostate) indicated a dose-related reduction in the rise of cancer-specific antigens used as surrogate markers for biological activity. The most common drug-related toxicity of marimastat in those clinical trials was musculoskeletal pain and stiffness, often commencing in the small joints and the hands, spreading to the arms and shoulder. A short dosing holiday of 1-3 weeks followed by dosage reduction permitted treatment to continue. (Rasmussen et al., *Pharmacol. Ther.*, 75(1), 69-75 (1997)) It is thought that the lack of specificity of inhibitory effect among the MMPs may be the cause of that effect.

The primary, secondary, and tertiary structures of the MMPs have a number of characteristic features. Each MMP contains a catalytic domain which in turn comprises a zinc binding site and an adjacent site known as the

S₁' pocket. The S₁' pocket has been recognized as a major factor in substrate specificity of the MMPs. See for example B. Lovejoy et al., *Nat. Struct. Biol.*, 6 (3), 217-221 (1999) at 218. The S₁' pocket is sometimes
5 known as the specificity pocket.

Figure 1 shows a partial sequence alignment for MMP-1, MMP-3, and MMP-8. The amino acid residues in the shaded boxes of Figure 1 comprise the residues included in the S₁' pocket for each of these MMPs. Symbols in
10 Figure 1 identifying the amino acid residues are commonly used by those of skill in the art. The primary, secondary, and tertiary structures work together for each MMP to provide the catalytic activity, kinetics, and substrate specificity of the enzyme.
15 These structures define the shape or conformation of the amino acid residue backbone of the enzyme. The actual sequence of amino acid residues in the S₁' pocket and the conformation of the residue backbone determine the specificity and kinetics of each MMP.

20 Some X-ray crystallographic experiments on MMPs are reported in the literature. For example, F. Grams et al. (*Euro J. Biochem.*, 228, 830-841 (1995)) discloses X-ray structures of human neutrophil collagenase complexed with peptidomimetic hydroxamate and thiol inhibitors.
25 In another report B. Lovejoy et al. (*Nat. Struct. Biol.*, 6 (3), 217-221 (1999)) disclose X-ray crystal structures of the catalytic domains of MMP-1 and MMP-13. Lovejoy et al. report that the MMP-1 S₁' pocket undergoes a conformational change to accommodate certain
30 diphenylether inhibitors but that the MMP-13 S₁' pocket is larger and can accommodate the diphenylether inhibitors without undergoing a conformational change. They report that this difference determines the selectivity of these diphenylether compounds for
35 preferentially inhibiting MMP-13 relative to MMP-1. The X-ray crystal structure for MMP-2 was reported by E.

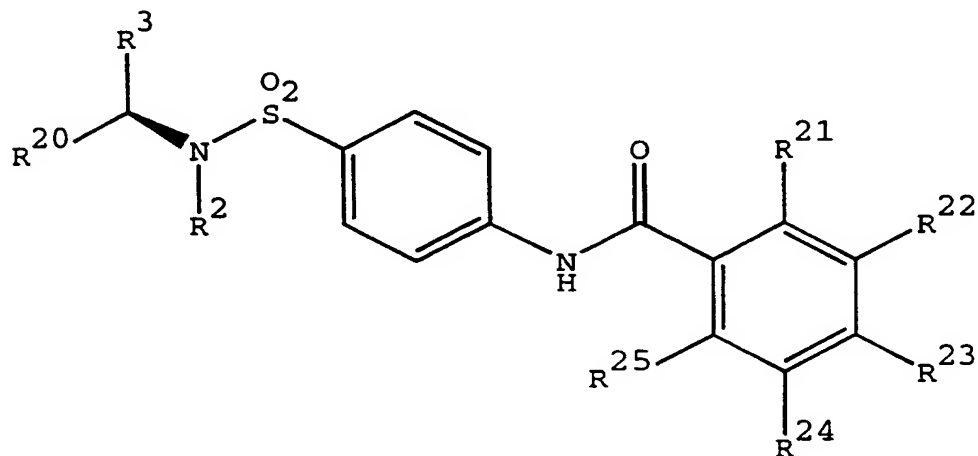
Morgunova et al. ("Structure of Human Pro-Matrix Metalloproteinase-2: Activation Mechanism Revealed," *Science* **284**, 1667-1670 (1999)).

5

Summary of the Invention

In view of the importance of MMP inhibitors in the treatment of several diseases and the lack of enzyme specificity exhibited by two of the more potent drugs now in clinical trials, it would be a great benefit if a new method were discovered by which to inhibit one or more MMP enzymes.

Among its several embodiments, the present invention provides a matrix metalloproteinase inhibiting compound having the structure:



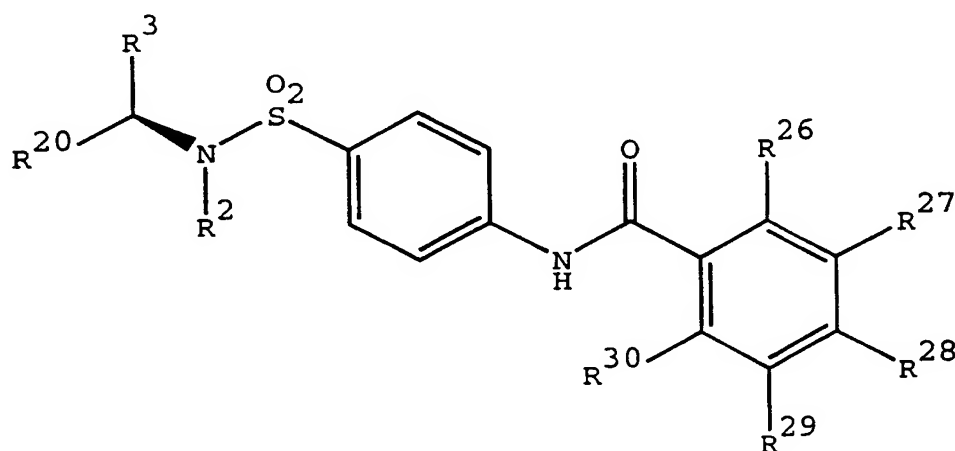
Formula VIII

or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof, wherein: R² is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, heterocycloalkyl, and heterocycloalkylalkyl; R³ is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl,

alkoxy, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, and heterocycloalkyl; R^{20} is selected from the group consisting of $-C(O)OH$, $-C(O)NHOH$, $-SH$, and $-C(O)SH$; and R^{21} , R^{22} , R^{23} , R^{24} , and R^{25} are

5 independently selected from the group consisting of H, C_1 to about C_{20} alkyl, C_1 to about C_{20} alkenyl, C_1 to about C_{20} alkynyl, cycloalkyl, haloalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, nitroalkyl, heterocycloalkyl, and carboxyalkyl.

10 The invention is further directed to a method of changing the conformation of a matrix metalloproteinase wherein the method comprises contacting the matrix metalloproteinase with a compound having the formula:



15

Figure XIII

or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof, thereby changing the conformation of the matrix metalloproteinase, wherein: R^2 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, heterocycloalkyl, and heterocycloalkylalkyl; R^3 is

25 selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxy, alkoxyalkyl, hydroxyalkyl, aminoalkyl,

alkylaminoalkyl, and heterocycloalkyl; R^{20} is selected from the group consisting of $-C(O)OH$, $-C(O)NHOH$, $-SH$, and $-C(O)SH$; and R^{26} , R^{27} , R^{28} , R^{29} , and R^{30} are independently selected from the group consisting of about C_3 to about C_{20} alkyl, about C_3 to about C_{20} alkenyl, about C_3 to about C_{20} alkynyl, cycloalkyl, haloalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, nitroalkyl, heterocycloalkyl, and carboxyalkyl.

10 The present invention is further provides a method of inhibiting a matrix metalloproteinase wherein the method comprises contacting the matrix metalloproteinase with a compound having the structure of Formula VIII or a salt, an enantiomer, a diastereomer, a racemate, or a
15 tautomer thereof, thereby inhibiting the matrix metalloproteinase.

 The present invention further provides a method of treating osteoarthritis in a mammal wherein the method comprises providing to the mammal an osteoarthritis-
20 treating-effective amount of a compound having the structure of Formula VIII or an enantiomer, diastereomer, racemate, or tautomer thereof, thereby treating osteoarthritis.

 Further scope of the applicability of the present
25 invention will become apparent from the detailed description provided below. However, it should be understood that the following detailed description and examples, while indicating preferred embodiments of the invention, are given by way of illustration only since
30 various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 shows a partial sequence alignment for MMP-1, MMP-3, and MMP-8.

5 Figure 2 shows the structures of inhibitor molecules of Formulae XII, IX, X, and XI superimposed upon one another.

Figure 3 shows MMP-8 S1' amino acid backbone residues which reside within 5 Å of a complexed
10 inhibitor molecule.

Figure 4 shows a comparison of the S1' pockets of MMP-1 and of MMP-8.

Figures 5, 6, 7, and 8 show the effect of progressively lengthening the P1' group of an MMP
15 inhibitor on the conformation of the substituents on amino acid residues of the S1' pocket.

Figures 9, 10, 11, and 12 show the effect of progressively lengthening the P1' group of an MMP
20 inhibitor on the conformation of the backbone of the S1' pocket.

Figure 13 shows the temperature factor (B) distribution for MMP-8 complexes with inhibitor compounds.

Figure 14 shows the (ϕ, ψ) distribution among the
25 amino acid residues of MMP-8 from 222 to 231.

Figures 15 and 16 show electron density distributions of one aspect of the overall MMP-8 enzyme when different inhibitor compounds have been complexed.

30 **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

The following detailed description is provided to aid those skilled in the art in practicing the present invention. Even so, this detailed description should
35 not be construed to unduly limit the present invention as modifications and variations in the embodiments

discussed herein can be made by those of ordinary skill in the art without departing from the spirit or scope of the present inventive discovery.

The contents of each of the references cited herein, including the contents of the references cited within these primary references, are herein incorporated by reference in their entirety.

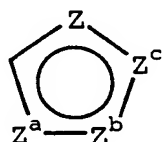
a. Definitions

The following definitions are provided in order to aid the reader in understanding the detailed description of the present invention:

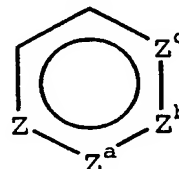
"Alkyl," "alkenyl," and "alkynyl" unless otherwise noted are each straight chain or branched chain hydrocarbons of from one to about 20 carbon atoms for alkyl or to about twenty carbon atoms for alkenyl and alkynyl. The terms therefore mean, for example, methyl, ethyl, propyl, butyl, pentyl, or hexyl; ethenyl, propenyl, butenyl, pentenyl, or hexenyl; and ethynyl, propynyl, butynyl, pentynyl, or hexynyl respectively and isomers thereof.

"Aryl" means a fully unsaturated mono- or multi-ring carbocycle, including but not limited to substituted or unsubstituted phenyl, naphthyl, or anthracenyl.

"Heterocycle" means a saturated or unsaturated mono- or multi-ring carbocycle wherein one or more carbon atoms can be replaced by N, S, P, or O. This includes, for example, the following structures:



or



30

wherein one or more of Z, Z^a, Z^b, or Z^c is independently C, S, P, or N, with the proviso that one of Z, Z^a, Z^b, or Z^c is other than carbon, but is not O or

S when attached to another Z atom by a double bond or when attached to another O or S atom. Furthermore, the optional substituents are understood to be attached Z, Z^a, Z^b, or Z^c only when the atom to which the optional
5 substituent is attached is C.

"Heteroaryl" means a fully unsaturated heterocycle.

In either "heterocycle" or "heteroaryl" the point of attachment to the molecule of interest can be at the heteroatom or elsewhere within the ring.

10 "Cycloalkyl" means a mono- or multi-ringed carbocycle wherein each ring contains three to about ten carbon atoms, and wherein any ring can contain one or more double or triple bonds.

The term "halogen" or "halo" means a fluoro,
15 chloro, bromo or iodo group.

The term "haloalkyl" means alkyl substituted with one or more halogens.

The term "diyl" means a diradical moiety wherein the moiety has two points of attachment to a molecule of
20 interest.

The term "heterocycloalkylalkyl" means an alkyl radical that is substituted with one or more heterocycle groups. Preferable heterocycloalkylalkyl radicals are "lower heterocycloalkylalkyl" radicals having one or
25 more heterocycle groups attached to an alkyl radical having one to ten carbon atoms.

When used in combination, for example "alkylaryl" or "arylalkyl," the individual terms listed above have the meaning indicated above.

30

b. Compounds

The compounds of the present invention can have at least two asymmetrical carbon atoms, and therefore
35 included racemates and stereoisomers such as diastereomers and enantiomers, in both pure form and in

admixture. Such stereoisomers can be prepared using conventional techniques, either by reacting enantiomeric starting materials, or by separating isomers of compounds of the present invention.

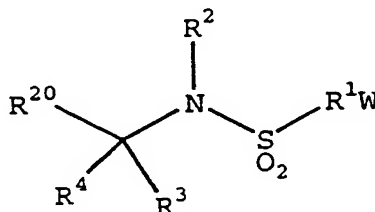
5 Isomers may include geometric isomers, for example cis isomers or trans isomers across a double bond. All such isomers are contemplated among the compounds of the present invention.

10 The compounds of the present invention also include their tautomers, salts, solvates, and prodrugs.

 In accordance with the present invention, it has been discovered that certain novel substituted-aromatic sulfonamide hydroxamic acid compounds and/or novel substituted-aromatic sulfonamide carboxylic acid
15 compounds are effective for inhibition of matrix metalloproteinases ("MMPs") believed to be associated with uncontrolled or otherwise pathological breakdown of connective tissue. In particular, it has been found that these substituted-aromatic ring sulfonamide
20 hydroxamic acid, substituted-aromatic ring sulfinamide hydroxamic acid, substituted-aromatic ring sulfenamide hydroxamic acid compounds, substituted-aromatic ring sulfonamide carboxylic acid, substituted-aromatic ring sulfinamide carboxylic acid or substituted-aromatic ring
25 sulfenamide carboxylic acid compounds are effective for inhibition of collagenase Type III (MMP-13) and neutrophil collagenase (collagenase II, MMP-8), which are believed to be particularly destructive to tissue if present or generated in abnormal quantities or
30 concentrations. Moreover, it has been discovered that many of these novel sulfur-nitrogen bonded compounds are selective in the inhibition of MMP-13, MMP-8, and/or other MMPs associated with diseased conditions without excessive inhibition of those collagenases essential to
35 normal bodily function such as tissue turnover and repair or other zinc proteases. More particularly, it

has been found that many of the substituted-aryl- or substituted-heteroaryl-sulfonamide hydroxamic acids of the invention are selective for MMP-13 or MMP-8 with limited or minimal effect on MMP-1.

- 5 Among its many embodiments, the present invention is directed to a matrix metalloproteinase inhibiting compound having the structure of Formula VII:



Formula VII

10

wherein:

W is independently selected from the group consisting of -NR⁵COR⁶, -NR⁵S(O)_zR⁷ where z is zero, 1, or 2, -NR⁵COOR⁸, -NR⁵CONR⁸R⁹ and -NR¹¹R¹².

- 15 R¹ is a hydrocarbyl diyl moiety or a substituted hydrocarbyl diyl moiety. R¹ can be aromatic, for example 1,2-phenylene, 1,3-phenylene, 1,4-phenylene, naphthalene-1,4-diyl, or naphthalene-1,5-diyl. Alternatively, R¹ can be aliphatic, for example
- 20 methylene, ethane-1,2-diyl, propane-1,2-diyl, or propane-1,3-diyl. R¹ can be a straight-chain hydrocarbyl diyl moiety, or it can be branched. For example, R¹ can be 2-methylpropane-1,3-diyl. Furthermore, R¹ can contain one or more unsaturations.
- 25 For example, R¹ can be prop-1-ene-1,3-diyl or a cycloalkylene such as anti-1,4-cyclohexane diyl. R¹ can also contain a heteroatom (e.g., O, N, or S). For example, R¹ can be a heteroarylene such as pyridine-2,5-diyl or R¹ can be an aliphatic heterocycle such as
- 30 morpholine-1,3-diyl. Where R¹ contains a heteroatom,

the point of attachment of R^1 to the molecule can be at a heteroatom of R^1 or it can be at a carbon atom of R^1 .

R^2 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, heterocycloalkyl, heterocycloalkylalkyl, aralkyl, heteroarylalkyl, cycloalkylalkyl, heterocycloalkylalkyl, alkoxyalkyl, alkylthioalkyl, hydroxycarbonylalkyl, alkylcycloalkyl, heterocycloalkylalkyl, aroylalkyl, and heteroaroylalkyl group, $-(CH_2)_x-NR^{11}R^{12}$, or $-(CH_2)_x-C(O)NR^{11}R^{12}$, wherein x is an integer from zero to 6.

R^3 and R^4 are independently selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxy, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, and heterocycloalkyl, aryl, aralkyl, thioalkyl, heteroaralkyl, heteroaryl, alkoxyalkoxyalkyl, trifluoromethylalkyl, alkoxycarbonylalkyl, aralkoxycarbonylalkyl, hydroxycarbonylalkyl, alkoxyalkyl, heterocycloalkylalkyl, aryloxyalkyl, alkylthioalkyl, arylthioalkyl, heteroarylthioalkyl group, or a sulfoxide or sulfone of any of said thio-containing groups, a $-(CH_2)_x-C(O)NR^{11}R^{12}$ group, wherein x is an integer from zero to 6, and a $-(CH_2)_y-W$ group, wherein y is an integer from 1 to 6 and W is defined above. Preferably, R^4 is H or a C_1 to about C_{12} alkyl group. More preferably, R^4 is H or a C_1 to about C_4 alkyl group. Still more preferably R^4 is H.

R^2 and R^3 together with the atom chain to which they are attached can optionally form a ring comprising about 3 to about 8 members.

R^4 is selected from the group consisting of H and C_1 to about C_{20} alkyl group.

R^5 is selected from the group consisting of H and C_1 to about C_{20} alkyl group.

R^6 is selected from the group consisting of H, cycloalkyl, heterocycloalkyl, aryl, heteroaryl, arylalkyl, alkylaryl, heteroaralkyl, cycloalkylalkyl, heterocycloalkylalkyl, alkoxyalkyl, alkylthioalkyl group, and a $-(CH_2)_x-NR^{11}R^{12}$ group wherein x is an integer from zero to about 6. The aryl or heteroaryl groups of R^6 are optionally substituted (unsubstituted or substituted) with one or more substituents independently selected from the group consisting of a halogen, C_1 to about C_{20} alkyl, C_1 to about C_{20} alkenyl, C_1 to about C_{20} alkynyl, C_1 to about C_{20} alkoxy, nitro, cyano, hydroxy, carboxy, hydroxycarbonylalkyl, $-(CH_2)_x-NR^{11}R^{12}$, wherein x is an number from zero to about 6, trifluoromethyl, alkoxycarbonyl, aminocarbonyl, thio, alkylsulfonyl, carbonylamino, aminosulfonyl, alkylsulfonamino, alkoxyalkyl, cycloalkyloxy, alkylthioalkyl or alkylthio.

Optionally, R^5 and R^6 together with the atom chain to which they are bonded can form an about 5- to about 7-membered a cyclic amide or imide that is substituted or unsubstituted.

Also optionally, R^5 and R^7 together with the atom chain to which they are bonded can form an about 5- to about 7-membered a cyclic sulfonamide that is substituted or unsubstituted.

R^7 is selected from the group consisting of R^6 and alkyl;

R^8 and R^9 are independently selected from the group consisting of R^6 and alkyl, or R^8 and R^9 together with the nitrogen atom to which they are attached form an about 5- to about 7-membered ring containing zero or one heteroatom that is oxygen, nitrogen or sulfur;

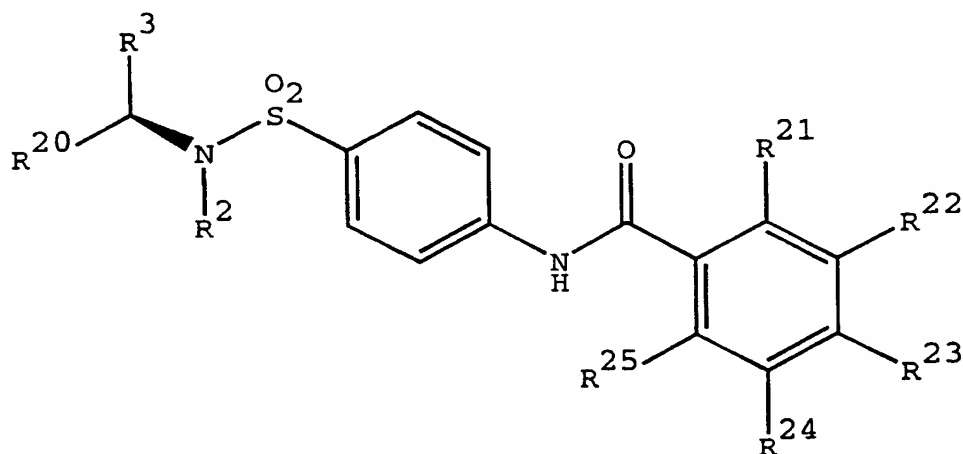
R^{11} and R^{12} are independently selected from the group consisting of H, alkyl, aryl, aralkyl, heteroaryl, heteroaralkyl, cycloalkyl, alkanoyl, aralkanoyl, and heteroaralkanoyl group, or R^{11} and R^{12} taken together

form an about 5- to about 8-membered heterocyclo or heteroaryl ring; and

R^{13} is selected from the group consisting of H or C_1 to about C_6 alkyl group.

5 R^{20} is selected from the group consisting of $-C(O)OH$, $-C(O)NHOH$, $-SH$, and $-C(O)SH$.

Preferably, the compound of the present invention has a structure of Formula VIII:



10

Formula VIII

or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof, wherein:

15 R^2 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, heterocycloalkyl, and heterocycloalkylalkyl;

20 R^3 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxy, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, haloalkoxy, haloalkylthio, and heterocycloalkyl;

25 R^{20} is selected from the group consisting of $-C(O)OH$, $-C(O)NHOH$, $-SH$, and $-C(O)SH$; and

R^{21} , R^{22} , R^{23} , R^{24} , and R^{25} are independently selected from the group consisting of H, C_1 to about C_{20} alkyl, C_1 to about C_{20} alkenyl, C_1 to about C_{20} alkynyl, cycloalkyl, haloalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, nitroalkyl, heterocycloalkyl, alkoxy, cycloalkoxy, alkoxycarbonyl, alkoxyalkyl, haloalkoxy, haloalkylthio, alkylamino, and carboxyalkyl.

Also, R^2 can be selected from the group consisting of any of the N-bonded substituent groups of the following bases: 4-acetyl cytidine; 5-(carboxyhydroxymethyl)uridine; 2'-O-methylpseudouridine; beta,D-galactosylquiosine; 2'-O-methylguanosine; inosine; N6-isopentenyladenosine; 1-methyladenosine; 1-methylpseudouridine; 1-methylguanosine; 1-methylinosine; 2,2-dimethylguanosine; 2-methyladenosine; 2-methylguanosine; 3-methylcytidine; 5-methylcytidine; N6-methyladenosine; 7-methylguanosine; 5-methoxyaminomethyl-2-thiouridine; beta, D-mannosylqueosine; 5-methoxycarbonylmethyluridine; 5-methoxyuridine; 2-methylthio-N6-isopentenyladenosine; N-((9-beta-D-ribofuranosyl-2-methylthiopurine-6-yl)carbamoyl)threonine; N-((9-beta-D-ribofuranolylpurine-6-yl)N-methyl-carbamoyl)threonine; uridine-5-oxyacetic methyl ester; uridine-5-oxyacetic acid (v); wybutoxosine; pseudouridine; queosine; 2-thiocytidine; 5-methyl-2-thiouridine; 2-thiouridine; 4-thiouridine; 5-methyluridine; N-((9-beta-D-ribofuranosylpurine-6-yl)carbamoyl)threonine; 2'-O-methyl-5-methyluridine; 2'-O-methyluridine; wybutosine; and 3-(3-amino-3-carboxypropyl)uridine, (acp3)u.

Further, R^2 can be selected from the group consisting of any of the side chains of the following amino acids: 2-aminoadipic acid; 3-aminoadipic acid; beta-alanine, beta-aminopropionic acid; 2-aminobutyric

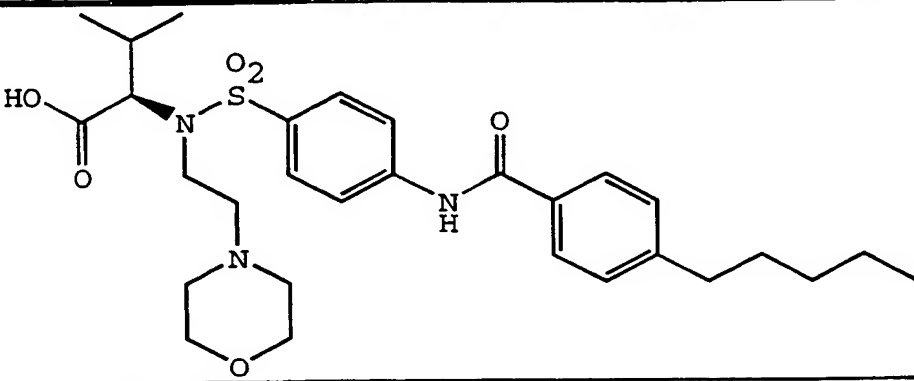
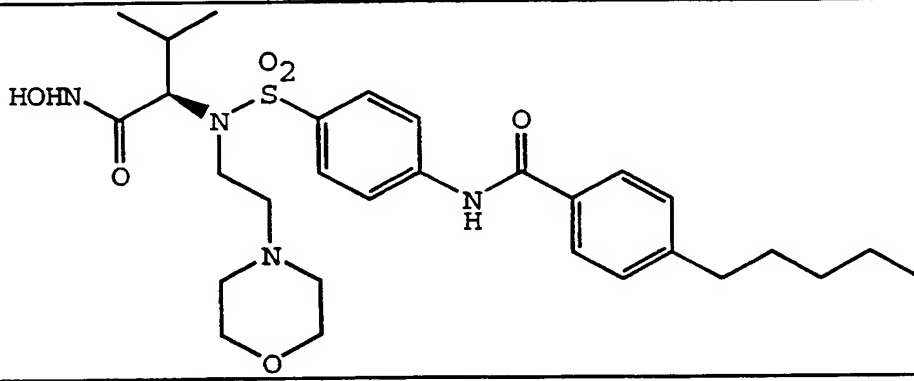
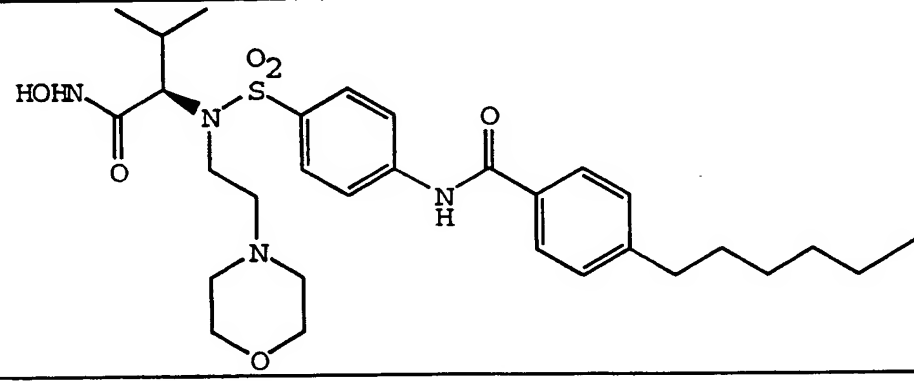
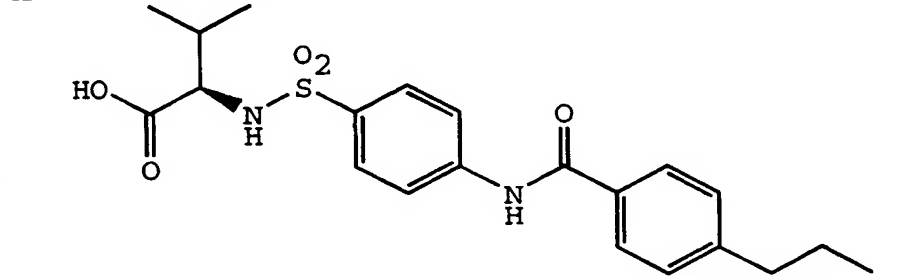
acid; 4-aminobutyric acid, piperidinic acid; 6-aminocaproic acid; 2-aminoheptanoic acid; 2-aminoisobutyric acid; 3-aminopimelic acid; 2,4-diaminobutyric acid; desmosine; 2,2'-diaminopimelic acid; 2,3-diaminopropionic acid; N-ethylglycine; N-ethylasparagine; hydroxylysine; allo-hydroxylysine; isodesmosine; allo-isoleucine; N-methylglycine, sarcosine; N-methylisoleucine; N-methylvaline; norvaline; norleucine; and ornithine.

- 10 Preferably, R^{20} of Formula VIII is selected from the group consisting of $-C(O)OH$ and $-C(O)NHOH$. Preferably R^{21} and R^{25} of Formula VIII are both H. More preferably, R^{21} , R^{22} , R^{24} , and R^{25} are H. When R^{21} , R^{22} , R^{24} , and R^{25} are H, preferably R^{23} is C_1 to about C_{20} alkyl and more preferably R^{23} is C_1 to about C_{20} linear alkyl.
- 15 When R^{20} of Formula VIII is $-C(O)OH$, R^3 is preferably selected from the group consisting of alkyl, alkenyl, alkynyl, haloalkoxy, haloalkylthio, and heterocycloalkyl; more preferably R^3 is
- 20 heterocycloalkyl, and more preferably still R^3 is 2-(N-morpholino)ethyl. When R^{20} of Formula VIII is $-C(O)NHOH$, R^3 is preferably selected from the group consisting of alkyl, alkenyl, alkynyl, haloalkoxy, haloalkylthio, and heterocycloalkyl; more preferably R^3 is
- 25 heterocycloalkyl, and more preferably still R^3 is 2-(N-morpholino)ethyl.

Table I below shows preferred compounds of the present invention. The represented compounds are meant to include their salts, enantiomers, diastereomers, racemates, and tautomers.

30

Table I.

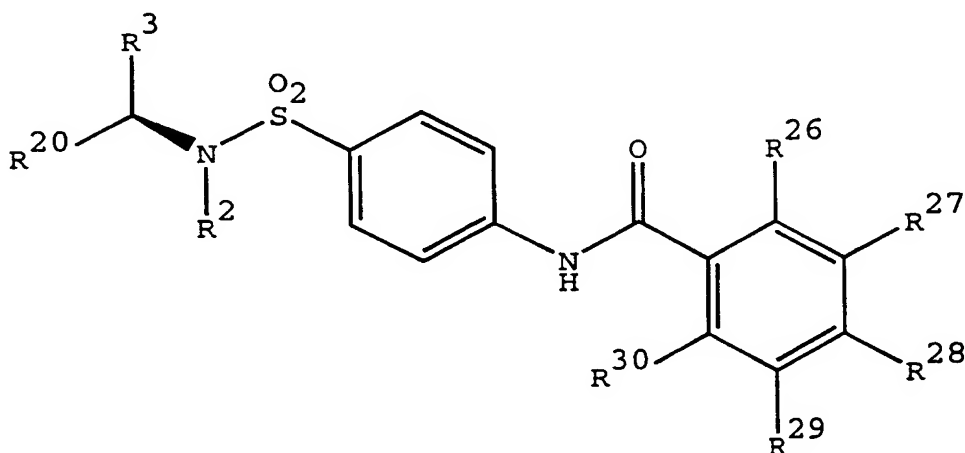
Formula Number	Structure
IX	
X	
XI	
XII	

Without being bound to a particular mechanism, it
5 is believed that some of the compounds of the present

invention provide selective inhibition of certain MMPs, particularly MMP-8 or MMP-13, in part by causing a change in the conformation of the amino acid residue backbone of the inhibited MMP.

5 The present invention is further directed to a method of changing the conformation of a matrix metalloproteinase wherein the method comprises contacting the matrix metalloproteinase with a compound having the structure of Formula XIII:

10



Formula XIII

or a salt, an enantiomer, a diastereomer, a racemate, or
15 a tautomer thereof, thereby changing the conformation of the matrix metalloproteinase, wherein:

R^2 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl,
20 aminoalkyl, alkylaminoalkyl, heterocycloalkyl, and heterocycloalkylalkyl;

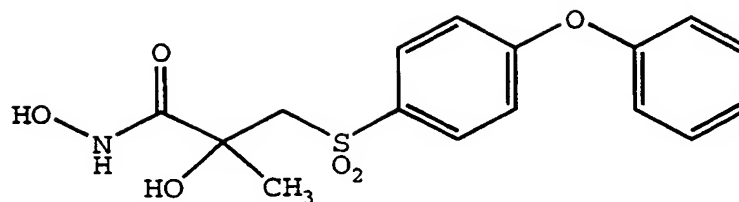
R^3 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxy, alkoxyalkyl, hydroxyalkyl,
25 aminoalkyl, alkylaminoalkyl, and heterocycloalkyl;

R^{20} is selected from the group consisting of -C(O)OH, -C(O)NHOH, -SH, and -C(O)SH; and

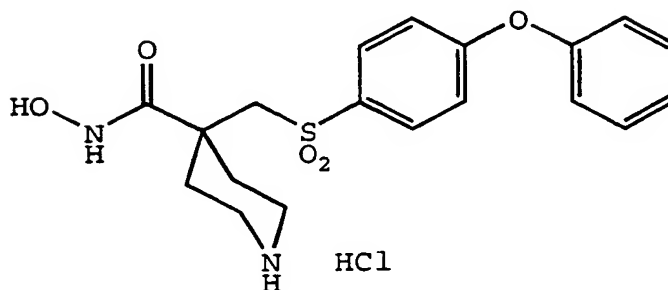
R^{26} , R^{27} , R^{28} , R^{29} , and R^{30} are independently selected from the group consisting of about C_3 to about C_{20} alkyl, about C_3 to about C_{20} alkenyl, about C_3 to about C_{20} alkynyl, cycloalkyl, haloalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, nitroalkyl, heterocycloalkyl, and carboxyalkyl.

Preferably for the method of changing the conformation of an MMP, R^{20} of Formula XIII is selected from the group consisting of $-C(O)OH$ and $-C(O)NHOH$. R^3 is preferably a C_1 to about C_{12} alkyl, more preferably R^3 is a C_1 to about C_4 alkyl, and more preferably still R^3 is isopropyl. R^2 is preferably heterocycloalkylalkyl and more preferably R^2 is 2-(N-morpholino)ethyl. Preferably R^{26} and R^{30} are H. More preferably, R^{26} , R^{27} , R^{29} , and R^{30} are H. R^{28} can be an alkyl group of any convenient size. When R^{26} , R^{27} , R^{29} , and R^{30} are H, R^{28} is preferably about C_3 to about C_{20} alkyl and more preferably R^{28} is about C_3 to about C_{20} linear alkyl. More preferably still R^{28} is n-propyl, n-butyl, n-pentyl or n-hexyl. Compounds IX, X, XI, and XII of Table I (or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof) each is useful in the present invention.

Surprisingly, the compounds of the Formula XIII are particularly useful in changing the conformation of MMP enzymes, especially MMP-8 and/or MMP-13. Crystal structures of MMP-8 complexed with MMP inhibitor compounds of Formula XIII compared with crystal structures of MMP-8 complexed with the compound of Formula XIV or the compound of Formula XV establish a three-dimensional structure-activity relationship.



Formula XIV



Formula XV

5

The catalytic domain (residues 85-242) of MMP-8, neutrophil collagenase, folds into a compact globular structure. It has an approximate diameter of 30 Å. The inhibitors interact with the protein through chelation of the catalytic zinc ion, hydrogen bonding with the backbone -NH- of Leu 160, and hydrophobic interactions in the nonpolar S1' pocket. In MMP-8, the S1' pocket is formed from residues 193-197 that form a turn of a longer helix and residues 214-229 of a loop region. The S1' pocket in MMP-8 is not as deep as in some other MMPs (e.g., stromelysin). The accompanying figures show the effect on the conformation of the S1' pocket as the P1' substituent on the inhibitor is made progressively longer.

Figure 2 shows the structures of inhibitor molecules of Formulae XII, IX, X, and XI superimposed upon one another, wherein the structures were determined by the X-ray crystallographic techniques described herein. The Figure shows the co-extensive reach of the

P1' arms of the inhibitors, except that as the alkyl group of the 4-alkylbenzamide moiety increases in length, the steric requirements of each inhibitor also increases. The P1' arm of each inhibitor fits into the
5 MMP-8 S1' pocket. In order to accommodate an increase in the steric requirement of the P1' arm, the amino acid residues of the S1' pocket must change their conformations.

Figure 3 shows MMP-8 S1' amino acid backbone
10 residues which reside within 5 Å of a complexed inhibitor molecule as determined by the X-ray crystallographic techniques described herein. A blank in Figure 3 indicates that the residue lies within 5 Å of the inhibitor whereas the word "no" indicates that
15 the residue lies further than 5 Å from the complexed inhibitor.

Figure 4 shows a comparison of the S1' pockets of MMP-1 and of MMP-8.

Figures 5, 6, 7, and 8 show the effect of
20 progressively lengthening the P1' group of the MMP inhibitor on the conformation of the substituents on amino acid residues of the S1' pocket.

Figure 5 shows a comparison of the X-ray crystallographic conformation of amino acid residues in
25 the S1' pocket of MMP-8 when either the compound of Formula XII (colored) or the compound of Formula XIV (grey) is complexed with MMP-8. The figure shows that the P1' group (including the 4-propylbenzamide moiety) of XII sterically interferes with the side chain of the
30 Arg 222 (R222) residue of the S1' pocket while the P1' group of XIV is much shorter and does not sterically interfere with the Arg 222 the side chain. Complexed XII causes the Arg 222 the side chain to move out of the way of the large P1' group of XII.

35 Figure 6 shows a comparison of the X-ray crystallographic conformation of amino acid residues in

the S1' pocket of MMP-8 when either the compound of Formula XII (colored) or the compound of Formula IX (grey) is complexed with MMP-8. The P1' group of IX (including the 4-pentylbenzamide moiety) is larger still than the P1' group of XII. Because of increased steric interference, the IX P1' group causes the the side chain of the Arg 222 (R222) residue of the S1' pocket to move even further away from the pocket than does the P1' group of XII.

Figure 7 shows a comparison of the X-ray crystallographic conformation of amino acid residues in the S1' pocket of MMP-8 when either the compound of Formula XII (colored) or the compound of Formula X (grey) is complexed with MMP-8. The P1' group of X (including the 4-hexylbenzamide moiety) is larger still than the P1' group of XII. Because of increased steric interference, the P1' group of X causes the side chain of the Arg 222 (R222) residue of the S1' pocket to move as far or further away from the pocket than does the XII P1' group.

Figure 8 shows a comparison of the X-ray crystallographic conformation of amino acid residues in the S1' pocket of MMP-8 when either the compound of Formula XII (colored) or the compound of Formula XI (grey) is complexed with MMP-8. This Figure shows a result similar to that of Figure 7.

Figures 9, 10, 11, and 12 show the effect of progressively lengthening the P1' group of the MMP inhibitor on the conformation of the backbone of the S1' pocket.

Figure 9 shows a comparison of the X-ray crystallographic conformation of the amino acid backbone of the S1' pocket of MMP-8 when either the compound of Formula XII (green) or the compound of Formula XIV (red) is complexed with MMP-8. Although Figure 9 demonstrates that XII affects the conformation of the side chain of

the Arg 222 (R222) residue of the S1' pocket relative to XIV, Figure 9 also shows that each compound has essentially no effect on the conformation of the amino acid backbone (shown as a ribbon in Figure 9). Tyr 227 (Y227) shows little change when either XII or XIV is complexed in the S1' pocket.

Figure 10 shows a comparison of the X-ray crystallographic conformation of the amino acid backbone of the S1' pocket of MMP-8 when either the compound of Formula XII (red) or the compound of Formula X (yellow) is complexed with MMP-8. The longer 4-pentylbenzamide moiety of X causes the backbone to deform significantly relative to the case in which XII is complexed. In addition, X causes the Arg 222 and Tyr 227 side chains to move significantly relative to the case in which XII is complexed.

Figure 11 shows a comparison of the X-ray crystallographic conformation of the amino acid backbone of the S1' pocket of MMP-8 when either the compound of Formula XII (red) or the compound of Formula IX (yellow) is complexed with MMP-8. The longer 4-pentylbenzamide moiety of IX causes the backbone to deform significantly relative to the case in which XII is complexed. In addition, IX causes the Arg 222 and Tyr 227 side chains to move significantly relative to the case in which XII is complexed.

Figure 12 shows a comparison of the X-ray crystallographic conformation of the amino acid backbone of the S1' pocket of MMP-8 when either the compound of Formula XII (red) or the compound of Formula XI (blue) is complexed with MMP-8. The longer 4-hexylbenzamide moiety of XI causes the backbone to deform significantly relative to the case in which XII is complexed. In addition, XI causes the Arg 222 and Tyr 227 side chains to move significantly relative to the case in which XII is complexed.

Figure 13 shows the temperature factor (B) distribution for MMP-8 complexes with inhibitor compounds XII (red), IX (orange), X (yellow), XI (blue), and XIV (white). Complexes with XII and XIV show similar temperature factors indicating that the MMP-8 backbone has similar thermal motion in both cases. However, XI, X, and IX complexes cause a progressive increase in the temperature factor in residues 221-230, indicating that they are causing greater thermal motion in that region of the S1' pocket of MMP-8 relative to compounds X or XIV.

Figure 14 shows the (ϕ, ψ) distribution among the amino acid residues of MMP-8 from 222 to 231.

Figure 15 shows an electrostatic surface of one aspect of the overall MMP-8 enzyme in which the inhibitor compound of Formula XIV has been complexed. Figure 16 shows an electrostatic surface of one aspect of the overall MMP-8 enzyme in which the inhibitor compound of Formula XI has been complexed. Figure 16 (center) shows that the XI has caused a change in the conformation of MMP-8 relative to XIV as evidenced by the opening created by XI in the S1' pocket caused by the change in conformation of the amino acid residue backbone of MMP-8. This opening is absent from the XIV-MMP-8 complex shown in Figure 15. The electrostatic surfaces were calculated and drawing using the GRASP program (A. Nicholls et al., "Protein folding and association: Insights from the interfacial and thermodynamic properties of hydrocarbons," *Protein Str. Funct. Gen.* 11, 281-296 (1991)).

These figures demonstrate that stepwise changes of the MMP-8 protein are observed in progressing from complexes of MMP-8 with XIV, XII, IX, X, and XI. The S1' pocket becomes deeper, first by the movement of amino acid residue side chains (especially Arg 222 and

Tyr 227), then by a movement of the backbone in the 224-228 region.

The present invention is also directed to a method of inhibiting a matrix metalloproteinase wherein the method comprises contacting the matrix metalloproteinase with a compound of Formula VIII (for which each of the substituents are as defined above) thereby inhibiting the matrix metalloproteinase. Preferably for the method of inhibiting an MMP, R^{20} of Formula XIII is selected from the group consisting of $-C(O)OH$ and $-C(O)NHOH$. R^3 is preferably a C_1 to about C_{12} alkyl, more preferably R^3 is a C_1 to about C_4 alkyl, and more preferably still R^3 is isopropyl. R^2 is preferably heterocycloalkylalkyl and more preferably R^2 is 2-(N-morpholino)ethyl. Preferably R^{21} and R^{25} of Formula VIII are both H. More preferably, R^{21} , R^{22} , R^{24} , and R^{25} are H. R^{23} can be an alkyl group of any convenient size. When R^{21} , R^{22} , R^{24} , and R^{25} are H, preferably R^{23} is C_1 to about C_{20} alkyl and more preferably R^{23} is C_1 to about C_{20} linear alkyl.

Compounds IX, X, XI, and XII of Table I (or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof) each is useful in the present invention. The compounds of the present invention are particularly useful in inhibiting MMP-8 and/or MMP-13.

Another embodiment of the present invention is directed toward a method for the treatment of osteoarthritis in a mammal wherein the method comprises providing to the mammal an osteoarthritis-treating-effective amount of a compound of Formula VIII (for which each of the substituents are as defined above). The mammal can be, for example, a human. Each of the compounds shown in Table I will be useful in the treatment of a human for osteoarthritis. Alternatively, the method for treating osteoarthritis can be directed to a veterinary subject, for example a cat or a dog.

c. Compound Syntheses

The starting materials for use in the preparation of the compounds of the present invention are known or can be prepared by conventional methods known to a skilled person or in an analogous manner to processes described in the art.

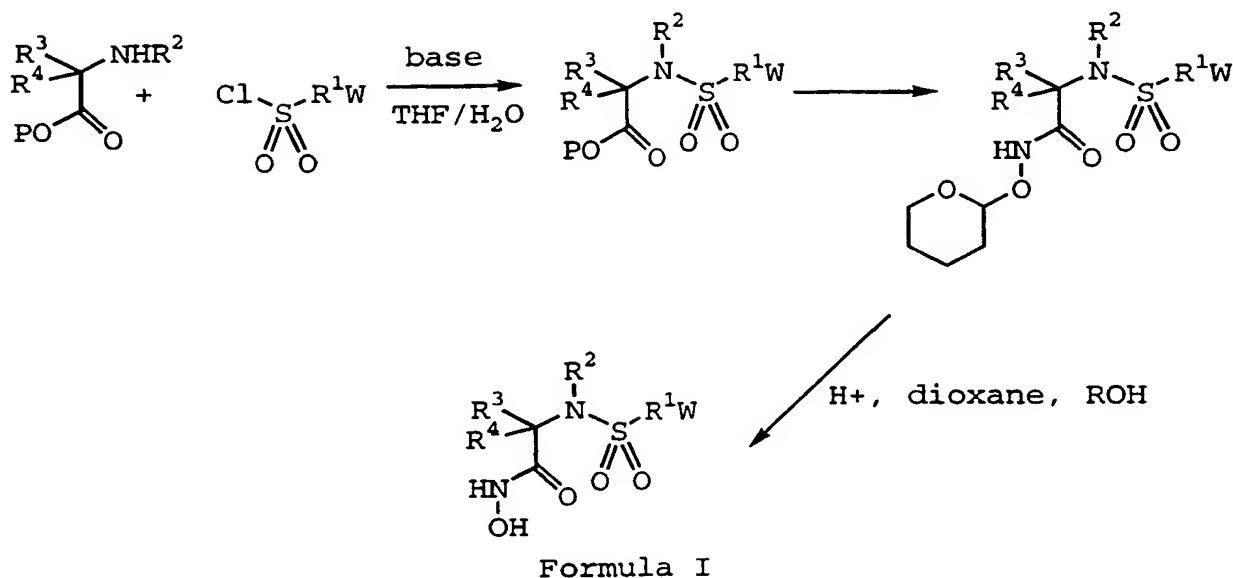
Generally, the compounds of the present invention can be prepared by methods described in detail in U.S. Patent Application No. 09/230,205, herein incorporated by reference.

Schemes I and III and Schemes 1, 2, 4, 5, 6, and 7 illustrate procedures with examples of chemical transformations that may be useful for the preparation of compounds of this invention. These syntheses, as with all of the reactions discussed herein, can be carried out under a dry inert atmosphere such as nitrogen or argon if desired. Selected reactions known to those skilled in the art, can be carried out under a dry atmosphere such as dry air whereas other synthetic steps, for example, aqueous acid or base ester or amide hydrolyses, can be carried out under laboratory air.

Thus, in general, the choices of starting material and reaction conditions can vary as is well known to those skilled in the art. Usually, no single set of conditions is limiting since variations can be applied as required. Conditions will also will be selected as desired to suit a specific purpose such as small scale preparations or large scale preparations. In either case, the use of less safe or less environmentally sound materials or reagents will usually be minimized.

Examples of such less desirable materials are diazomethane, diethyl ether, heavy metal salts, dimethyl sulfide, chloroform, benzene and the like.

Scheme 1



P = H, protecting group

Scheme 1 shows the conversion of an N-substituted
 5 alpha-amino acid, protected or unprotected, into a
 compound of Formula I. The amino acid may be protected
 with a group P such as an alkyl ester such as methyl,
 ethyl, tert-butyl, tetrahydropyranyl and the like or
 arylalkyl ester such as benzyl. Treatment of this amine
 10 with a sulfonyl, sulfinyl or sulfenyl chloride would
 provide the corresponding amide. A base would normally
 be used to inactivate the HCl released from the acid
 chloride and it would be such that it would not react
 with the sulfonyl chloride, i.e., ammonia, primary or
 15 secondary amines would not normally be used. Examples
 of bases that can be used include, for example, metal
 hydroxides such as sodium, potassium, lithium or
 magnesium hydroxide, oxides such as those of sodium,
 potassium, lithium, calcium or magnesium, metal
 20 carbonates such as those of sodium, potassium, lithium,
 calcium or magnesium, metal bicarbonates such as sodium

bicarbonate or potassium bicarbonate, primary, secondary or tertiary organic amines such as alkyl amines, arylalkyl amines, alkylarylalkyl amines, heterocyclic amines or heteroaryl amines, ammonium hydroxides or

5 quaternary ammonium hydroxides. As non-limiting examples, such amines can include triethyl amine, trimethyl amine, diisopropyl amine, methyldiisopropyl amine, diazabicyclononane, tribenzyl amine, dimethylbenzyl amine, morpholine, N-methylmorpholine,

10 N,N'-dimethylpiperazine, N-ethylpiperidine, 1,1,5,5-tetramethylpiperidine, dimethylaminopyridine, pyridine, quinoline, tetramethylethylenediamine and the like. Non-limiting examples of ammonium hydroxides, usually made from amines and water, can include ammonium

15 hydroxide, triethyl ammonium hydroxide, trimethyl ammonium hydroxide, methyldiisopropyl ammonium hydroxide, tribenzyl ammonium hydroxide, dimethylbenzyl ammonium hydroxide, morpholinium hydroxide, N-methylmorpholinium hydroxide, N,N'-dimethylpiperazinium

20 hydroxide, N-ethylpiperidinium hydroxide, and the like. As non-limiting examples, quaternary ammonium hydroxides can include tetraethyl ammonium hydroxide, tetramethyl ammonium hydroxide, dimethyldiisopropyl ammonium hydroxide, benzylmethyldiisopropyl ammonium hydroxide,

25 methyldiazabicyclononyl ammonium hydroxide, methyltribenzyl ammonium hydroxide, N,N'-dimethylmorpholinium hydroxide, N,N,N',N'-tetramethylpiperazinium hydroxide, and N-ethyl-N'-hexylpiperidinium hydroxide and the like. Metal

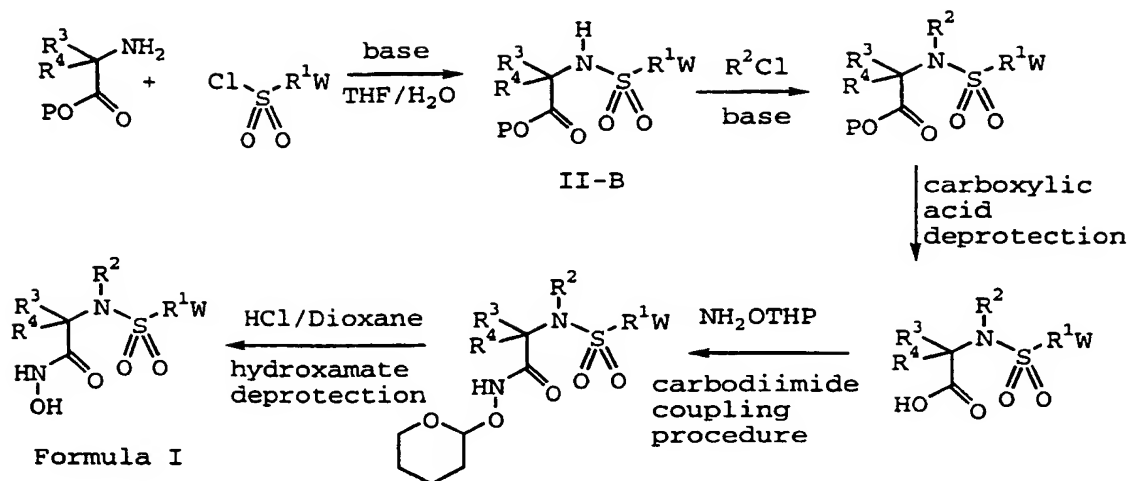
30 hydrides, amide or alcoholates such as calcium hydride, sodium hydride, potassium hydride, lithium hydride, sodium methoxide, potassium tert-butoxide, calcium ethoxide, magnesium ethoxide, sodium amide, potassium diisopropyl amide and the like may also be suitable

35 reagents. Organometallic deprotonating agents such as alkyl or aryl lithium reagents such as methyl, phenyl or

butyl lithium, Grignard reagents such as methylmagnesium bromide or methylmagnesium chloride, organocadmium reagents such as dimethylcadmium and the like may also serve as bases for causing salt formation or catalyzing the reaction. Quaternary ammonium hydroxides or mixed salts are also useful for aiding phase transfer couplings or serving as phase transfer reagents.

The first reaction in Scheme 1 also illustrated the use of a mixed solvent THF/H₂O. This is one solvent system however others may be useful also. For example, the reaction media can consist of a single solvent, mixed solvents of the same or different classes or serve as a reagent in a single or mixed solvent system. The solvents can be protic, non-protic or dipolar aprotic. Non-limiting examples of protic solvents include water, methanol (MeOH), denatured or pure 95% or absolute ethanol, isopropanol and the like. Typical non-protic solvents include acetone, tetrahydrofuran (THF), dioxane, diethylether (ether), tert-butylmethyl ether (TBME), aromatics such as xylene, toluene, or benzene, ethyl acetate, methyl acetate, butyl acetate, trichloroethane, methylene chloride, ethylenedichloride (EDC), hexane, heptane, isooctane, cyclohexane and the like. Dipolar aprotic solvents include compounds such as dimethylformamide (DMF), dimethylacetamide (DMAc), acetonitrile, nitromethane, tetramethylurea, N-methylpyrrolidone and the like.

Scheme 2



P = H, protecting group

Non-limiting examples of ammonium hydroxides, usually made from amines and water, can include ammonium hydroxide, triethyl ammonium hydroxide, trimethyl ammonium hydroxide, methyldiisopropyl ammonium hydroxide, tribenzyl ammonium hydroxide, dimethylbenzyl ammonium hydroxide, morpholinium hydroxide, N-methylmorpholinium hydroxide, N,N'-dimethylpiperazinium hydroxide, N-ethylpiperidinium hydroxide, and the like. As non-limiting examples, quaternary ammonium hydroxides can include tetraethyl ammonium hydroxide, tetramethyl ammonium hydroxide, dimethyldiisopropyl ammonium hydroxide, benzylmethyldiisopropyl ammonium hydroxide, methyldiazabicyclononyl ammonium hydroxide, methyltribenzyl ammonium hydroxide, N,N'-dimethylmorpholinium hydroxide, N,N,N',N'-tetramethylpiperazinium hydroxide, and N-ethyl-N'-hexylpiperidinium hydroxide and the like. Metal hydrides, amide or alcoholates such as calcium hydride, sodium hydride, potassium hydride, lithium hydride, sodium methoxide, potassium tert-butoxide, calcium

ethoxide, magnesium ethoxide, sodium amide, potassium diisopropyl amide and the like may also be suitable reagents. Organometallic deprotonating agents such as alkyl or aryl lithium reagents such as methyl, phenyl or butyl lithium, Grignard reagents such as methylmagnesium bromide or methylmagnesium chloride, organocadmium reagents such as dimethylcadmium and the like may also serve as bases for causing salt formation or catalyzing the reaction. Quaternary ammonium hydroxides or mixed salts are also useful for aiding phase transfer couplings or serving as phase transfer reagents.

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Non-limiting examples of reagents that can be used as solvents or as part of a mixed solvent system include organic or inorganic mono- or multi-protic acids or bases such as hydrochloric acid, phosphoric acid, sulfuric acid, acetic acid, formic acid, citric acid,

succinic acid, triethylamine, morpholine, N-methylmorpholine, piperidine, pyrazine, piperazine, pyridine, potassium hydroxide, sodium hydroxide, alcohols, ammonia or amines for making esters or amides and the like.

Acids are used in many reactions during various synthesis. Scheme 1 illustrates acid use for the removal of the THP protecting group to produce the hydroxamic acid of Formula I. The acid might be mono-, di- or tri-protic organic or inorganic acids. Examples of acids include hydrochloric acid, phosphoric acid, sulfuric acid, acetic acid, formic acid, citric acid, succinic acid, hydrobromic acid, hydrofluoric acid, carbonic acid, phosphorus acid, p-toluene sulfonic acid, trifluoromethane sulfonic acid, trifluoroacetic acid, difluoroacetic acid, benzoic acid, methane sulfonic acid, benzene sulfonic acid, 2,6-dimethylbenzene sulfonic acid, trichloroacetic acid, nitrobenzoic acid, dinitrobenzoic acid, trinitrobenzoic acid, and the like. They might also be Lewis acids such as aluminum chloride, borontrifluoride, antimony pentafluoride and the like. A preferred solvent in this type reaction is dioxane either an alcohol or water however almost any solvent system with one component being a protic solvent can be useful.

Scheme I illustrates conversion of a carboxylic acid protected as an ester or amide into an hydroxamic acid derivative such as a O-arylalkylether or O-cycloalkoxyalkylether group. In particular, in this Scheme the protecting group on the hydroxylamine is the THP group. In the case where hydroxylamine is used, treatment of an ester or amide with one or more equivalents of hydroxylamine hydrochloride at room temperature or above in a solvent or solvents, usually protic or partially protic, such as those listed above can provide a hydroxamic acid directly. This exchange

process may be further catalyzed by the addition of additional acid. Alternatively, a base such as a salt of an alcohol used as a solvent, for example, sodium methoxide in methanol, can be used to form hydroxylamine from hydroxylamine hydrochloride in situ which can exchange with an ester or amide. As mentioned above, exchange can be carried out with a protected hydroxylamine such as tetrahydropyranyl-hydroxyamine (THPONH₂), benzylhydroxylamine (BnONH₂), and the like in which case compounds such as shown in Scheme 1 that are tetrahydropyranyl (THP) or benzyl (Bn) hydroxamic acid derivatives are the products. Removal of the protecting groups when desired, for example, following further transformations in another part of the molecule or following storage, is accomplished by standard methods well known in the art such as acid hydrolysis of the THP group as discussed above or reductive removal of the benzyl group with hydrogen and a metal catalyst such as palladium, platinum, palladium on carbon or nickel.

In the case where P is hydrogen, i.e., where the intermediate is a carboxylic acid, standard coupling reactions can be used. For example, the acid can be converted into an acid chloride, mixed anhydride or activated ester and treated with hydroxylamine or a protected hydroxylamine in the presence of a non-competitive base to the nitrogen acylated compound. This is the same product as discussed above. Couplings of this nature are well known in the art and especially the art related to peptide and amino acid chemistry.

Scheme II illustrates another possible synthesis of the compounds of Formula I starting with a protected or unprotected amino acid. Sulfonylation of the amino group is accomplished as discussed above to produce the sulfonamide II-B. This compound is a secondary sulfonamide and, as such, is acidic and can be alkylated with an R² group. Alkylation, a process well known in

the art, can be carried by treatment of the sulfonamide with base to form the corresponding anion, adding an electrophilic reagent and allowing the SN_2 reaction to proceed. Electrophiles include halogen derivatives, sulfonate esters, epoxides and the like. The bases and solvents discussed with regard to Scheme I are applicable in this Scheme. Preferred bases are those that are hindered such that competition with the electrophile is minimized. Additional preferred bases are metal hydrides, amide anions or organometallic bases such as a butyl lithium. The solvents, solvent mixtures or solvent/reagent mixtures discussed are satisfactory but non-protic or dipolar aprotic solvents such as acetone, acetonitrile, DMF and the like are examples of preferred classes.

Scheme III illustrates the potential for use of a sulfonyl chloride reagent, specifically nitrobenzenesulfonyl chloride, to prepare compounds of this invention. It should be noted that this reagent is for illustration and is not to be considered limiting or required. After coupling with an amino acid and alkylation of the coupling product if required, the nitrosulfonamide can be reduced to provide a useful amino compound. The amino group can be alkylated if desired. It can also be acylated with an aroyl chloride, heteroaryl or other R^6 amine carbonyl froming agent to form a $-C(=O)-$ or $-S(=O)_n-$ compound of this invention. The amino sulfonamide can also be reacted with a carbonic acid ester chloride as shown in Scheme IV, a sulfonyl chloride as shown in Scheme V or in Scheme VII or a carbamoyl chloride or isocyanate as shown in Scheme VI to produce the corresponding carbamate, sulfonamides, or ureas of this invention. Acylation of amines of this type are well known in the art and the reagents are also well known. Usually these reactions are carried out in aprotic solvents under an

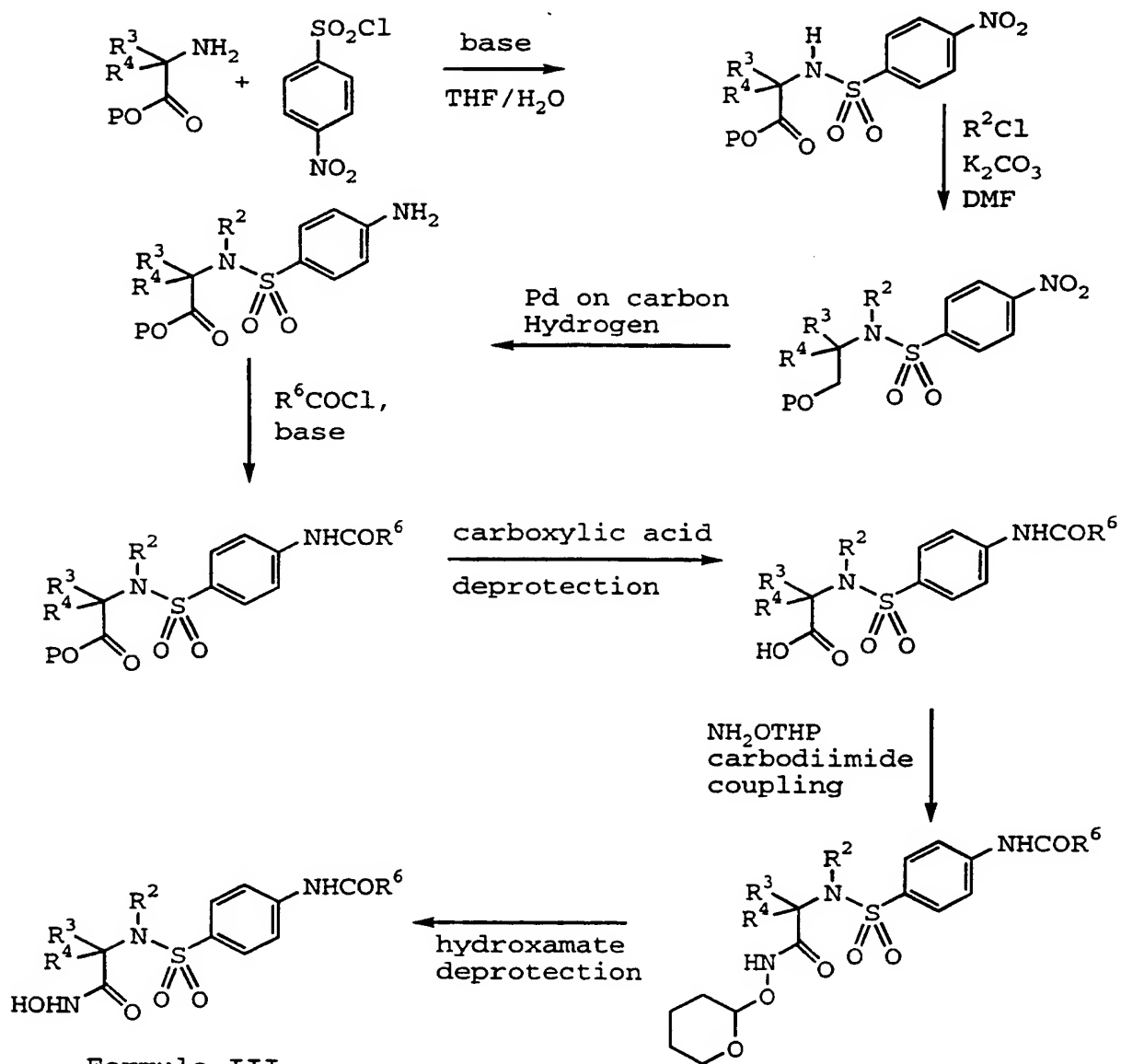
inert or/and dry atmosphere at about 45°C to about -
10°C. An equivalent of a non-competitive base is
usually used with sulfonyl chloride, acid chloride or
carbonyl chloride reagents. Following this acylation
5 step, synthesis of the hydroxamic acid products of this
invention can proceed as discussed above for Scheme I
and Scheme II.

Schemes II through VI also illustrate the possible
reduction of a nitrobenzenesulfonamide to produce an
10 amino sulfonamide. The reduction of nitro groups to
amines is well known in the art with a preferred method
being hydrogenation. There is usually a metal catalyst
such as Rh, Pd, Pt, Ni or the like with or without an
additional support such as carbon, barium carbonate and
15 the like. Solvents can be protic or non-protic pure
solvents or mixed solvents as required. The reductions
can be carried out at atmospheric pressure to a pressure
of multiple atmospheres with atmospheric pressure to
about 40 pounds per square inch (psi) preferred.

20 Other sulfonyl chloride reagents can also be used
in the preparation of compounds of this invention as
outlined in the Schemes. Examples are fluoroaryl or
fluoroheteroaryl sulfonyl chlorides, azidoaryl or
azidoheteroaryl or amide, carbonate, carbamate or urea
25 substituted aryl or heteroaryl sulfonyl chloride
reagents. Azides, for example, can be reduced to an
amino group using hydrogen with a metal catalyst or
metal chelate catalyst or activated hydride transfer
reagent. The fluoro substituted sulfonic acid or
30 sulfonamide can be treated with a nucleophile such as
ammonia or a primary amine, under pressure if desired,
to provide an amino or substituted (R5) amino group that
can then be reacted with a reagent as outlined in Scheme III
and in Schemes 4-7 inclusive.

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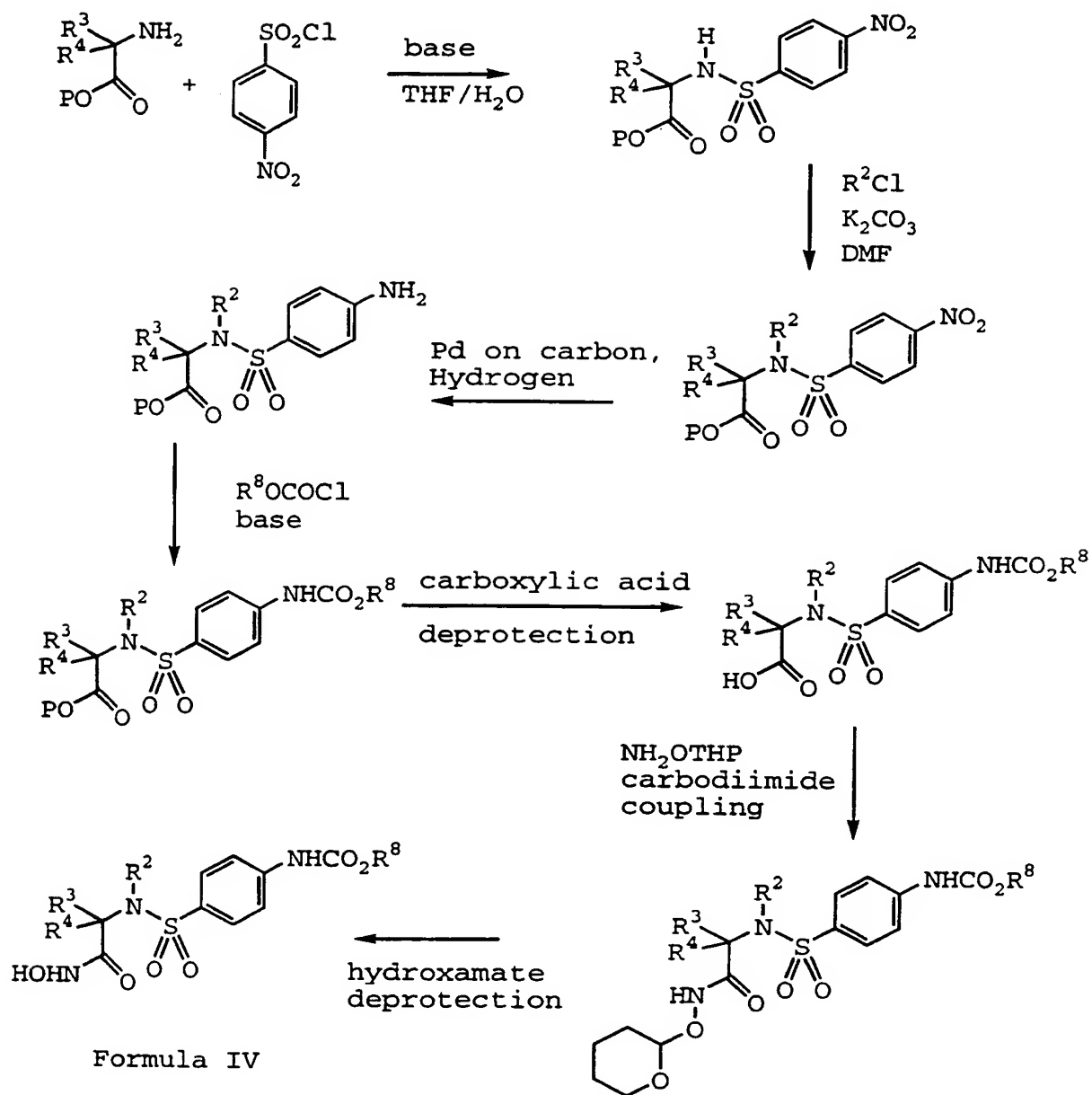
Scheme III



Formula III

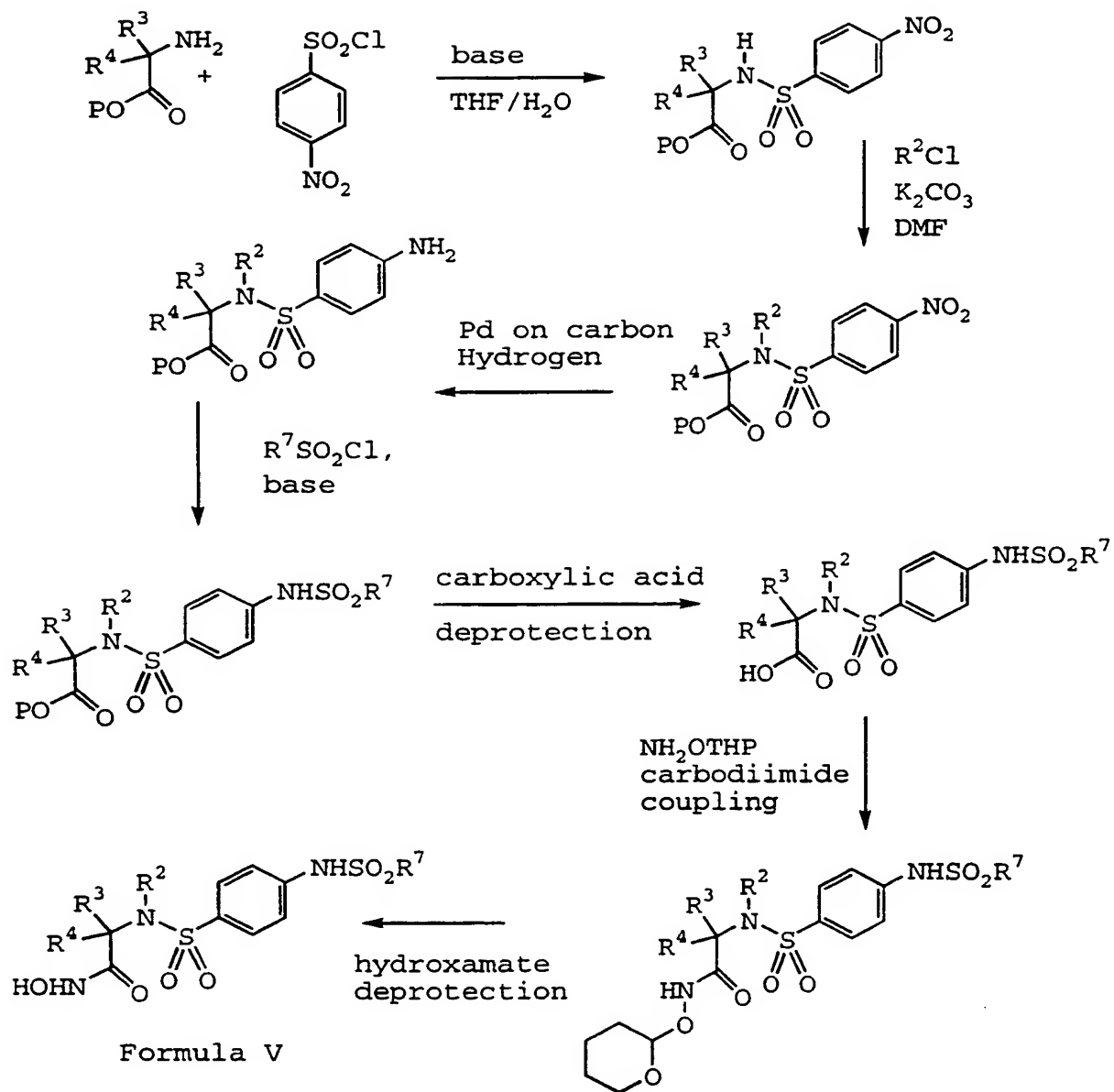
P = H, protecting group

Scheme 4



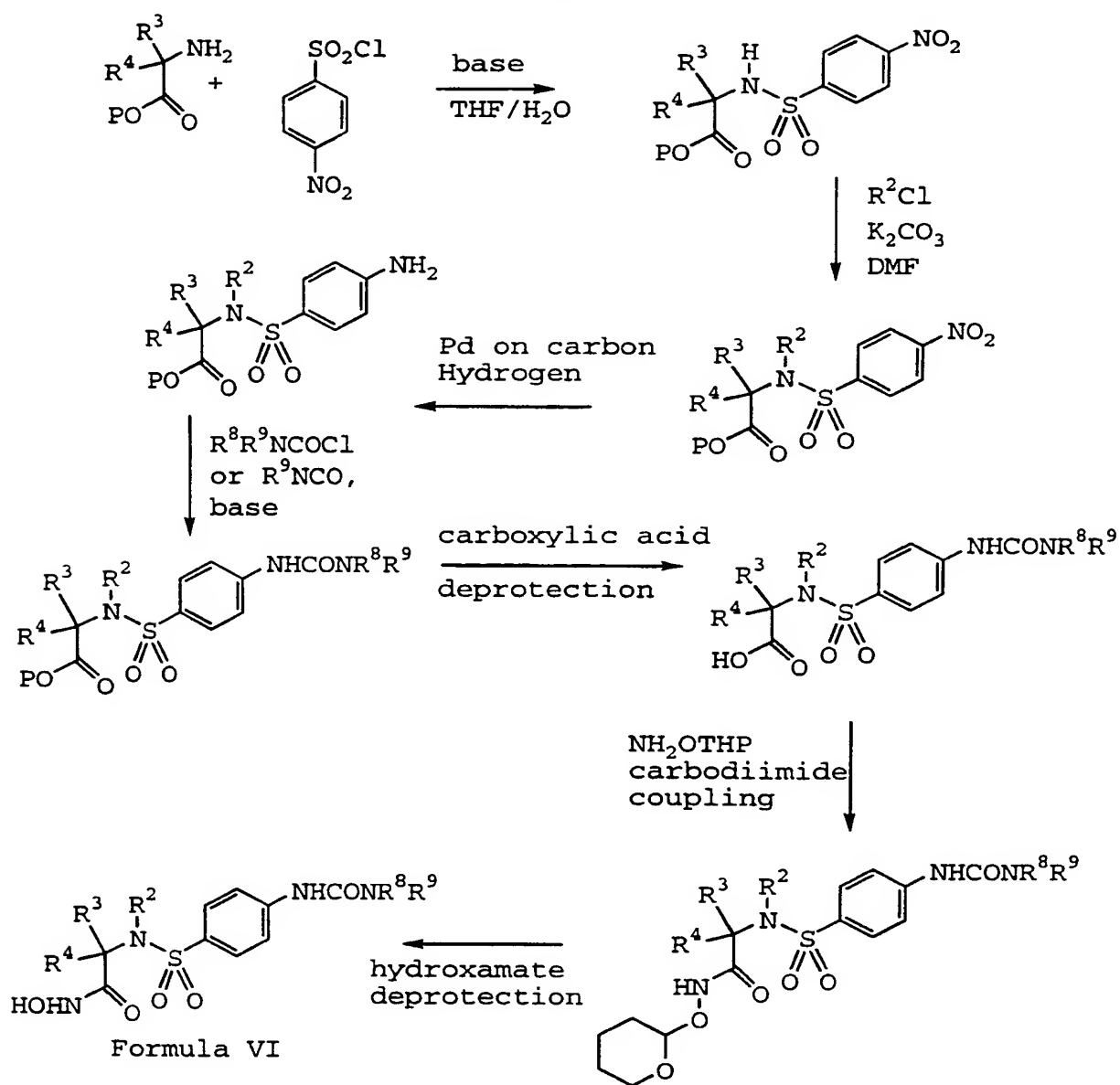
P = H, protecting group

Scheme 5



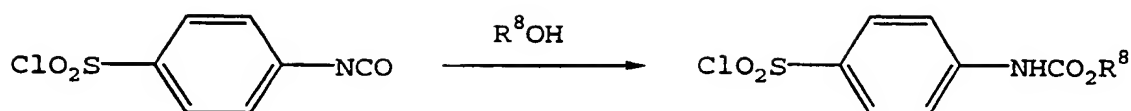
P = H, protecting Group

Scheme 6



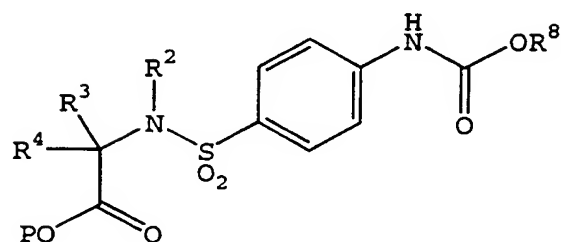
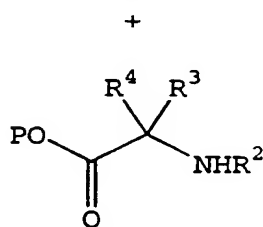
P = H, protecting group

Scheme 7



Intermediate IV-A

Intermediate IV-A



Intermediate VI-C

Compounds of the present can possess one or more
5 asymmetric carbon atoms and are thus capable of existing
in the form of optical isomers as well as in the form of
racemic or nonracemic mixtures thereof. The optical
isomers can be obtained by resolution of the racemic
mixtures according to conventional processes well known
10 in the art, for example by formation of
diastereoisomeric salts by treatment with an optically
active acid or base. Examples of appropriate acids are
tartaric, diacetyltartaric, dibenzoyltartaric,
ditoluoyltartaric and camphorsulfonic acid and then
15 separation of the mixture of diastereoisomers by
crystallization followed by liberation of the optically
active bases from these salts. A different process for
separation of optical isomers involves the use of a
chiral chromatography column optimally chosen to
20 maximize the separation of the enantiomers. Still
another available method involves synthesis of covalent

diastereoisomeric molecules, e.g., esters, amides, acetals, ketals, and the like, by reacting compounds of Formula I with an optically active acid in an activated form, a optically active diol or an optically active isocyanate. The synthesized diastereoisomers can be separated by conventional means such as chromatography, distillation, crystallization or sublimation, and then hydrolyzed to deliver the enantiomerically pure compound. In some cases hydrolysis to the parent optically active drug is not necessary prior to dosing the patient since the compound can behave as a prodrug. The optically active compounds of Formula I can likewise be obtained by utilizing optically active starting materials.

Contemplated equivalents of the general formulas set forth above for the MMP inhibitor compounds and derivatives as well as the intermediates are compounds otherwise corresponding thereto and having the same general properties such as tautomers thereof and compounds wherein one or more of the various R groups are simple variations of the substituents as defined therein, e.g., wherein R is a higher alkyl group than that indicated. In addition, where a substituent is designated as, or can be, a hydrogen, the exact chemical nature of a substituent which is other than hydrogen at that position, e.g., a hydrocarbyl radical or a halogen, hydroxy, amino and the like functional group, is not critical so long as it does not adversely affect the overall activity and/or synthesis procedure. For example, two hydroxyl groups, two amino groups, two thiol groups or a mixture of two hydrogen-heteroatom groups on the same carbon are known not to be stable without protection or as a derivative.

The chemical reactions described above are generally disclosed in terms of their broadest application to the preparation of the compounds of this invention. Occasionally, the reactions may not be applicable as

described to each compound included within the disclosed scope. The compounds for which this occurs will be readily recognized by those skilled in the art. In all such cases, either the reactions can be successfully performed by conventional modifications known to those skilled in the art, e.g., by appropriate protection of interfering groups, by changing to alternative conventional reagents, by routine modification of reaction conditions, and the like, or other reactions disclosed herein or otherwise conventional, will be applicable to the preparation of the corresponding compounds of this invention. In all preparative methods, all starting materials are known or can be readily prepared from known starting materials.

15

d. Treatment Methods

A process for treating a host mammal having a condition associated with pathological matrix metalloproteinase activity is also contemplated. That process comprises administering a metalloproteinase inhibitor described hereinbefore in an MMP enzyme-inhibiting effective amount to a mammalian host having such a condition. The use of administration repeated a plurality of times is particularly contemplated.

A contemplated inhibitor compound is used for treating a host mammal such as a mouse, rat, rabbit, dog, horse, primate such as a monkey, chimpanzee or human that has a condition associated with pathological matrix metalloproteinase activity.

Also contemplated is the similar use of a contemplated metalloproteinase inhibitor compound in the treatment of a disease state that can be affected by the activity of metalloproteinases such as TNF- α convertase. Exemplary of such disease states are the acute phase responses of shock and sepsis, coagulation responses,

hemorrhage and cardiovascular effects, fever and inflammation, anorexia and cachexia.

In treating a disease condition associated with pathological matrix metalloproteinase activity, a contemplated MMP inhibitor compound can be used, where appropriate, in the form of an amine salt derived from an inorganic or organic acid. Exemplary acid salts include but are not limited to the following: acetate, adipate, alginate, citrate, aspartate, benzoate, benzenesulfonate, bisulfate, butyrate, camphorate, camphorsulfonate, digluconate, cyclopentanepropionate, dodecylsulfate, ethanesulfonate, glucoheptanoate, glycerophosphate, hemisulfate, heptanoate, hexanoate, fumarate, hydrochloride, hydrobromide, hydroiodide, 2-hydroxy-ethanesulfonate, lactate, maleate, methanesulfonate, nicotinate, 2-naphthalenesulfonate, oxalate, palmoate, pectinate, persulfate, 3-phenylpropionate, picrate, pivalate, propionate, succinate, tartrate, thiocyanate, tosylate, mesylate and undecanoate.

Also, a basic nitrogen-containing group can be quaternized with such agents as lower alkyl (C_1 - C_6) halides, such as methyl, ethyl, propyl, and butyl chloride, bromides, and iodides; dialkyl sulfates like dimethyl, diethyl, dibutyl, and diamyl sulfates, long chain (C_8 - C_{20}) halides such as decyl, lauryl, myristyl and dodecyl chlorides, bromides and iodides, aralkyl halides like benzyl and phenethyl bromides, and others to provide enhanced water-solubility. Water or oil-soluble or dispersible products are thereby obtained as desired. The salts are formed by combining the basic compounds with the desired acid.

Other compounds useful in this invention that are acids can also form salts. Examples include salts with alkali metals or alkaline earth metals, such as sodium,

potassium, calcium or magnesium or with organic bases or basic quaternary ammonium salts.

In some cases, the salts can also be used as an aid in the isolation, purification or resolution of the compounds of this invention.

Total daily dose administered to a host mammal in single or divided doses of an MMP enzyme-inhibiting effective amount can be in amounts, for example, of about 0.001 to about 30 mg/kg body weight daily and more usually about 0.01 to about 10 mg. Dosage unit compositions can contain such amounts or submultiples thereof to make up the daily dose. A suitable dose can be administered, in multiple sub-doses per day. Multiple doses per day can also increase the total daily dose, should such dosing be desired by the person prescribing the drug.

The dosage regimen for treating a disease condition with a compound and/or composition of this invention is selected in accordance with a variety of factors, including the type, age, weight, sex, diet and medical condition of the patient, the severity of the disease, the route of administration, pharmacological considerations such as the activity, efficacy, pharmacokinetic and toxicology profiles of the particular compound employed, whether a drug delivery system is utilized and whether the compound is administered as part of a drug combination. Thus, the dosage regimen actually employed can vary widely and therefore can deviate from the preferred dosage regimen set forth above.

A compound useful in the present invention can be formulated as a pharmaceutical composition. Such a composition can then be administered orally, parenterally, by inhalation spray, rectally, or topically in dosage unit formulations containing conventional nontoxic pharmaceutically acceptable

carriers, adjuvants, and vehicles as desired. Topical administration can also involve the use of transdermal administration such as transdermal patches or iontophoresis devices. The term parenteral as used
5 herein includes subcutaneous injections, intravenous, intramuscular, intrasternal injection, or infusion techniques. Formulation of drugs is discussed in, for example, Hoover, John E., Remington's Pharmaceutical Sciences, Mack Publishing Co., Easton, Pennsylvania;
10 1975 and Liberman, H.A. and Lachman, L., Eds., Pharmaceutical Dosage Forms, Marcel Decker, New York, N.Y., 1980.

Injectable preparations, for example, sterile injectable aqueous or oleaginous suspensions can be
15 formulated according to the known art using suitable dispersing or wetting agents and suspending agents. The sterile injectable preparation can also be a sterile injectable solution or suspension in a nontoxic parenterally acceptable diluent or solvent, for example,
20 as a solution in 1,3-butanediol. Among the acceptable vehicles and solvents that can be employed are water, Ringer's solution, and isotonic sodium chloride solution. In addition, sterile, fixed oils are conventionally employed as a solvent or suspending
25 medium. For this purpose any bland fixed oil can be employed including synthetic mono- or diglycerides. In addition, fatty acids such as oleic acid find use in the preparation of injectables. Dimethyl acetamide, surfactants including ionic and non-ionic detergents,
30 polyethylene glycols can be used. Mixtures of solvents and wetting agents such as those discussed above are also useful.

Suppositories for rectal administration of the drug can be prepared by mixing the drug with a suitable
35 nonirritating excipient such as cocoa butter, synthetic mono-, di-, or triglycerides, fatty acids and

polyethylene glycols that are sold at ordinary temperatures but liquid at the rectal temperature and will therefore melt in the rectum and release the drug.

Solid dosage forms for oral administration can include capsules, tablets, pills, powders, and granules. In such solid dosage forms, the compounds of this invention are ordinarily combined with one or more adjuvants appropriate to the indicated route of administration. If administered per os, the compounds can be admixed with lactose, sucrose, starch powder, cellulose esters of alkanolic acids, cellulose alkyl esters, talc, stearic acid, magnesium stearate, magnesium oxide, sodium and calcium salts of phosphoric and sulfuric acids, gelatin, acacia gum, sodium alginate, polyvinylpyrrolidone, and/or polyvinyl alcohol, and then tableted or encapsulated for convenient administration. Such capsules or tablets can contain a controlled-release formulation as can be provided in a dispersion of active compound in hydroxypropylmethyl cellulose. In the case of capsules, tablets, and pills, the dosage forms can also comprise buffering agents such as sodium citrate, magnesium or calcium carbonate or bicarbonate. Tablets and pills can additionally be prepared with enteric coatings.

For therapeutic purposes, formulations for parenteral administration can be in the form of aqueous or non-aqueous isotonic sterile injection solutions or suspensions. These solutions and suspensions can be prepared from sterile powders or granules having one or more of the carriers or diluents mentioned for use in the formulations for oral administration. The compounds can be dissolved in water, polyethylene glycol, propylene glycol, ethanol, corn oil, cottonseed oil, peanut oil, sesame oil, benzyl alcohol, sodium chloride, and/or various buffers. Other adjuvants and modes of

administration are well and widely known in the pharmaceutical art.

Liquid dosage forms for oral administration can include pharmaceutically acceptable emulsions, solutions, suspensions, syrups, and elixirs containing inert diluents commonly used in the art, such as water. Such compositions can also comprise adjuvants, such as wetting agents, emulsifying and suspending agents, and sweetening, flavoring, and perfuming agents.

The amount of active ingredient that can be combined with the carrier materials to produce a single dosage form varies depending upon the mammalian host treated and the particular mode of administration.

Certain of the sulfonamide, sulfinamide or sulfenamide, compounds of this invention that are administered in accordance with an above-discussed process can serve as prodrugs to other compounds of this invention. Prodrugs are drugs that can be chemically converted *in vivo* or *in vitro* by biological systems into an active derivative or derivatives. Prodrugs are administered in essentially the same manner as the other pharmaceutical compounds of the invention.

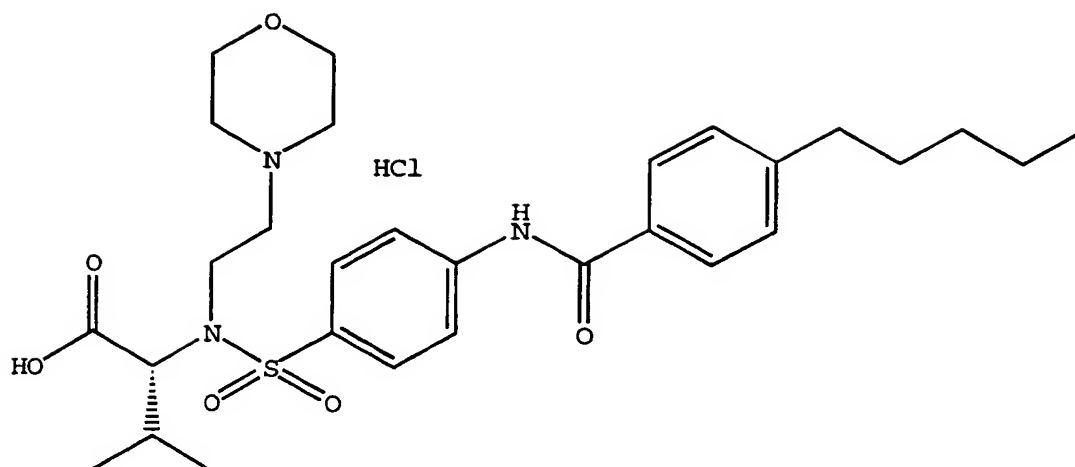
e. Detailed Preparative and Crystallographic Methods

The starting materials for use in the methods of preparation of the invention are known or can be prepared by conventional methods known to a skilled person or in an analogous manner to processes described in the art.

Generally, the process methods of the present invention can be performed as follows.

Example 1.

N-[2-(4-morpholinyl)ethyl]-N-[[4-[(4-pentylbenzoyl)amino]phenyl]sulfonyl]-D-valine (IX)



Part A: To a solution of D-valine (25.0 g, 213
5 mmol) in H₂O (180 mL) and acetone (96 mL) was added
triethylamine (62 mL, 448 mmol) and was cooled to zero
degrees Celsius. To this solution was added 4-
nitrobenzenesulfonyl chloride (45.3 g, 204 mmol) in
acetone (100 mL) dropwise. The solution was stirred for
10 72 hours. The solution was concentrated *in vacuo* and
the resulting aqueous layer was extracted with toluene
and acidified to pH = 2 with 2N HCl. The aqueous layer
was extracted with ethyl acetate three times and the
combined organic layers were washed with saturated NaCl
15 and dried over MgSO₄. Concentration *in vacuo* provided
the sulfonamide as a light brown solid (37.15 g, 61 %).

Part B: A solution of the sulfonamide of part A
(37.15 g, 123 mmol) and a catalytic amount of H₂SO₄ in
dichloromethane/dioxane (1L) was subjected to
20 isobutylene for 18 hours. The solution was cooled to
zero degrees Celsius and quenched with saturated NaHCO₃.
The aqueous layer was extracted with ethyl acetate and
the organic layer was washed with saturated NaCl and
dried over MgSO₄. Chromatography (on silica, ethyl
25 acetate/hexane) provided the t-butyl ester as a solid
(16.7 g, 38 %).

Part C: To a solution of the t-butyl ester of part B (16.5 g, 46 mmol) in DMF (60 mL) was added 4-(2-chloroethyl) morpholine hydrochloride (17.2 g, 92 mmol) and K₂CO₃ (25.5 g, 184 mmol) and the solution was heated to sixty degrees Celsius for 7 hours. The solution was partitioned between ethyl acetate and H₂O and the organic layer was washed with saturated NaCl and dried over Na₂SO₄. Chromatography (on silica, ethyl acetate/hexane) provided the morpholine compound as a solid (21.5 g, 99 %).

Part D: To a solution of the morpholine compound of part C (21.5 g, 45.6 mmol) in THF (200 mL) in a flask purged with H₂ was added 4% Pd/C (3.04 g) and the solution was hydrogenated until uptake ceased. The solution was filtered through Celite® to remove the excess catalyst and the filtrate was concentrated *in vacuo* to provide the aniline as an oil (19.2 g, 95 %).

Part E: To a solution of the aniline of part D (2.60 g, 5.88 mmol) in THF (20 mL) was added triethylamine (3.2 mL, 22.8 mmol) and the solution was cooled to four degrees Celsius. To this solution was added 4-pentylbenzoyl chloride (2.1 g, 10.0 mmol) and the solution was stirred for 18 hours at ambient temperature. The solution was concentrated *in vacuo* and the residue was partitioned between ethyl acetate and saturated NaHCO₃. The organic layer was washed with saturated NaHCO₃ and saturated NaCl and dried over Na₂SO₄. Chromatography (ethyl acetate/hexane) provided the benzamide as a solid (2.09 g, 58 %).

Part F: A solution of the benzamide of part E (2.09 g, 3.4 mmol) in 4N HCl (20 mL) was stirred for 72 hours. The solution was concentrated *in vacuo* and the residue was dissolved into ethyl acetate (5 mL) and dropped into ethyl ether. The resulting precipitate was collected by vacuum filtration to provide R-N-[4-[[[1-carboxyl]-2-methylpropyl][2-(4-orpholinyl)ethyl]amino]-

sulfonyl]phenyl]-4-pentylbenzamide, monohydrochloride as a white solid (1.9 g, 94 %).

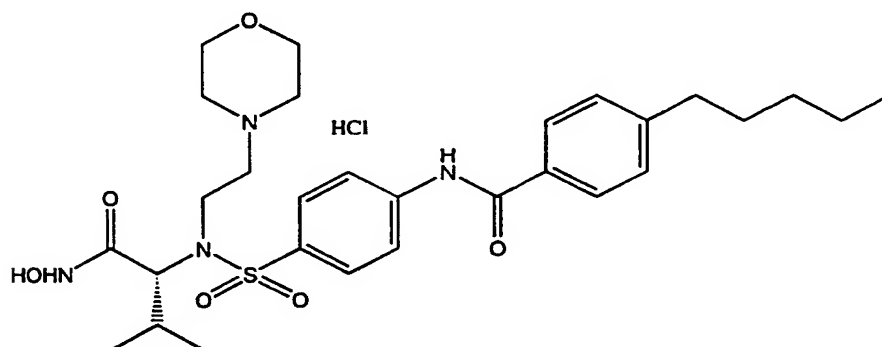
MS(CI) MH^+ calculated for $C_{29}H_{41}N_3O_6S$: 560, found: 560.

5

Example 2.

R-N-[4-[[[1-(hydroxyamino)carbonyl]-2-methylpropyl][2-(4-morpholinyl)ethyl]amino]-sulfonyl]phenyl]-4-pentylbenzamide, monohydrochloride (X)

10



Part A: To a solution of the acid of Example 1, part F (1.52 g, 2.56 mmol) in DMF (5 mL) was added N-hydroxybenzotriazole (414 mg, 3.07 mmol) and the solution was cooled to four degrees Celsius. To this solution was added 4-methylmorpholine (1.69 mL, 15.6 mmol), 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (687 mg, 3.58 mmol) and tetrahydropyranyl hydroxylamine (449 mg, 3.84 mmol) and was stirred for 1 hour at ambient temperature. The solution was partitioned between ethyl acetate and saturated NaHCO₃ and the organic layer was washed with saturated NaHCO₃, saturated NaCl and H₂O and dried over Na₂SO₄. Chromatography (ethyl acetate/methanol) provided the ester as a solid (1.54 g, 91 %).

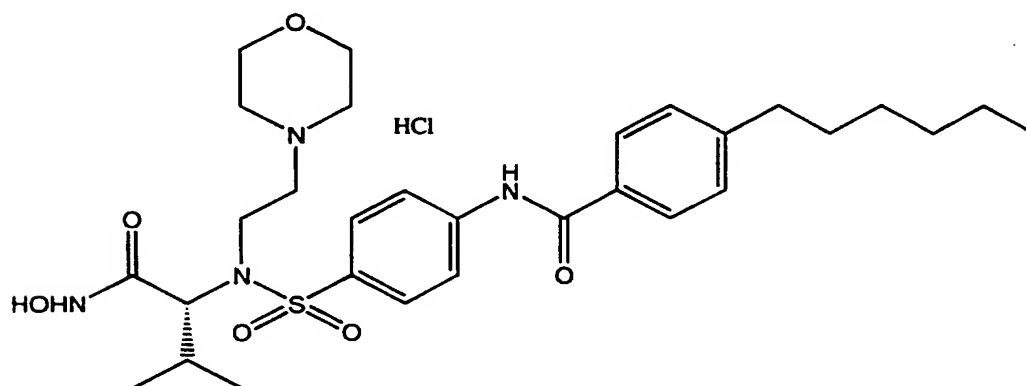
Part B: To a solution of the ester of part A (1.54 g, 2.34 mmol) in methanol (1 mL) was added 4N HCl (10 mL) and the solution was stirred for 18 hours at ambient

temperature. The solution was concentrated *in vacuo*. Reverse phase chromatography (on silica, acetonitrile/H₂O(HCl)) provided the title compound, R-N-[4-[[[1-(hydroxyamino)carbonyl]-2-methylpropyl][2-(4-morpholinyl)ethyl]amino]sulfonyl]phenyl]-4-pentylbenzamide, monohydrochloride, as a white solid (745 mg, 52 %). MS(CI) MH⁺ calculated for C₂₉H₄₂N₄O₆S: 575, found: 575.

10

Example 3.

(R)-4-hexyl-N-[4-[[[1-(hydroxyamino)-carbonyl]-2-methylpropyl][2-(4-morpholinyl)ethyl]amino]sulfonyl]-phenylbenzamide, monohydrochloride (XI)



15

Part A: To a solution of the aniline of Example 1, part D (2.5 g, 5.7 mmol) was added triethylamine (3.2 mL, 22.8 mmol) and the solution was cooled to four degrees Celsius. To this solution was added 4-hexylbenzoyl chloride (2.18 g, 9.69 mmol) and the solution was stirred overnight at ambient temperature. The solution was concentrated *in vacuo* and the residue was partitioned between ethyl acetate and saturated NaHCO₃. The organic layer was washed with saturated NaHCO₃ and saturated NaCl and dried over Na₂SO₄. Chromatography (on silica, ethyl acetate/hexane) provided the benzamide as a solid (2.76 g, 77 %).

Part B: A solution of the benzamide of part A (2.7 g, 4.3 mmol) in 4N HCl in dioxane (20 mL) was stirred for 72 hours. The solution was concentrated in vacuo and the residue was dissolved into ethyl acetate (5 mL).
5 This solution was dropped into ethyl ether. The resulting precipitate was collected by vacuum filtration to provide the acid as a solid (2.5 g, 95 %).

Part C: To a solution of the acid of part B (2.03 g, 3.33 mmol) in DMF (5 mL) was added
10 N-hydroxybenzotriazole (540 mg, 4.00 mmol) and the solution was cooled to four degrees Celsius. To this solution was added 4-methylmorpholine (2.19 mL, 20.0 mmol), 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (894 mg, 4.66 mmol) and tetrahydropyranyl
15 hydroxylamine (615 mg, 5.00 mmol) and the solution was stirred for 1 hour at ambient temperature. The solution was partitioned between ethyl acetate and saturated NaHCO₃ and the organic layer was washed with saturated NaHCO₃, saturated NaCl and H₂O and dried over Na₂SO₄.
20 Chromatography (on silica, ethyl acetate/methanol) provided the ester as a solid (2.01 g, 90 %).

Part D: To a solution of the ester of part C (2.01 g, 3.24 mmol) in methanol (1 mL) was added 4N HCl (10 mL) and the solution was stirred for 18 hours at ambient
25 temperature. Reverse phase chromatography (on silica, acetonitrile/H₂O(0.05% HCl)) provided the title compound, (R)-4-hexyl-N-[4-[[[1-(hydroxyamino)carbonyl]-2-methylpropyl][2-(4-morpholinyl)ethyl]amino]sulfonyl]-phenylbenzamide, monohydrochloride, as a white solid
30 (1.23 g, 61 %). MS(CI) MH⁺ calculated for C₃₀H₄₄N₄O₆S: 589, found: 589.

Example 4.

Cloning, expression and purification of the catalytic
35 **domain of MMP-8.**

The MMP-8 catalytic domain was cloned by PCR amplification from a cDNA construct of full-length MMP-8. The amplified DNA was cloned into NdeI/HindIII restriction sites in an in-house pRec expression vector. Protein was expressed in a bacterial expression system by induction with nalidixic acid. Recombinant protein was expressed primarily as inclusion bodies. Purified protein was recovered in high yield following ion exchange chromatography of denatured protein. Refolding from denaturant and subsequent purification using a second ion exchange step resulted in active protein that was used for crystallography.

Crystallization of inhibitor complexes.

Crystals were grown by vapor equilibration in sitting drops following a procedure similar to that described by Bode et al. ("The X-ray crystal structure of the catalytic domain of human neutrophil collagenase inhibited by a substrate analogue reveals the essentials for catalysis and specificity," *FEBS Letters* **338**, 227-233 (1994).) A solution of the enzyme inhibitor complex is mixed with a precipitating reagent to form the sitting drop which is equilibrated against a high-salt solution. Slow dehydration of the drop leads to formation of single crystals of the inhibitor complex. Details are below.

Protein: 12 mg/ml MMP-8 in 10 mM MES pH 6.0, 100 mM NaCl, 5 mM CaCl₂ pre-incubated with 1 mM inhibitor for 10 minutes at ambient temperature.

Sitting Drop: 4 ul of the protein-inhibitor complex mixed with 6.8 ul 10% PEG6000 and 0.2 M MES pH 6.0

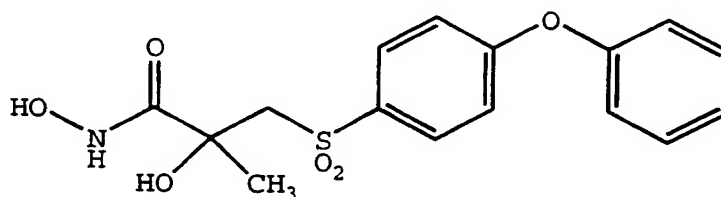
Reservoir: 0.8 to 2.5 M sodium/potassium phosphate pH 6.0 (not mixed with protein/inhibitor/PEG drop).

X-ray Data Collection.

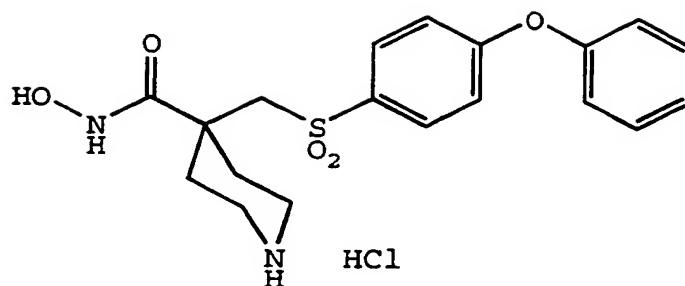
5 Intensities from crystals of the enzyme inhibitor complexes were measured on a MAR image plate at -140 °C. X-rays were generated from a rotating anode generator using a Cu target. The CuK α X-rays were focused onto the samples using long Pt and Ni mirrors.

10 The data were integrated and scaled using the program DENZO (Otwinowski, Z. and Minor W. in *Proceedings of CCP4 Study Weekend: Data Collection and Processing* (eds. Sawyer, L., Issacs, N., and Bailey, S.) pp. 56-62 (SERC Daresbury Laboratories, Warrington, UK
15 1993)).

The structures for compounds XIV and XV are shown below. Compound XIV is described in U.S. Patent Application No. 09/254,535, herein incorporated by reference. Compound XV is described in U.S. Patent
20 Application No. 09/254,530, herein incorporated by reference.



Formula XIV



Formula XV

Statistics for six data sets are given in the
Tables II and III below:

Space Group: $P2_12_12_1$

5

Table II

Compound with which MMP-8 catalytic domain (residues 85-242) are com- plexed ^a	a ^b	b ^b	c ^b	Res- olu- tion ^c	Rsym ^d	I/sig ^e
XII	32.97	68.92	70.61	1.65	0.050(0.209)	21.8(3.4)
IX	33.05	68.59	68.55	1.64	0.078(0.326)	10.9(1.7)
X	33.50	68.79	69.34	1.65	0.084(0.257)	12.4(2.7)
XI	33.31	68.50	67.01	1.83	0.097(0.467)	14.2(2.9)
XIV	32.43	68.16	72.08	1.46	0.029(0.078)	25.6(11.9)
XV	32.40	68.26	71.70	1.43	0.079(0.307)	15.9(2.4)

10

Table III

Compound with which MMP-8 catalytic domain (residues 85-242) are complexed ^a	total ^f	unique ^g	redundant ^h	coverage ⁱ
XII	52840	18220	2.9	90.7(66.8)
IX	42171	17815	2.4	90.9(76.1)
X	39481	15999	2.5	87.2(80.6)

XI	46758	14042	3.3	97.6(97.3)
XIV	70996	26770	2.5	93.8(82.5)
XV	107545	29122	3.7	96.4(87.3)

^aInhibitor code;

^blattice constants (unit cell dimensions).

^cdata resolution;

5 ^dR_{sym} (internal consistency) for overall and
highest resolution shell;

^eI/sigma (signal/noise ratio) for overall and
highest resolution shell;

^ftotal number of observations collected;

10 ^gnumber of unique reflections;

^hredundancy;

ⁱdata coverage (completeness in %) for overall and
highest resolution shell.

15 **Structure Solution and Model Building and Refinement.**

Coordinates of the structure of MMP-8 in complex
with batimastat (4-(N-hydroxyamino)-2R-isobutyl-2S-(2-
thienylthiomethyl)succinyl-L-phenylalanine-N-
methyleamide) were obtained from the Protein Data Bank

20 (accession number: 1mmb) Coordinates of only the
protein atoms and the metal ions were used in an initial
refinement with the X-ray data collected on the new
complexes. Standard simulated annealing protocols in the
program XPLOR (Brünger, A.T. (1993). *XPLOR (Version*
25 *3.1): A System for X-ray Crystallography and NMR* (Yale
University Press, New Haven, CT)) were used. The
refined positional and thermal parameters were used to
calculate new phases for display of Fo-Fc and 2Fo-Fc
electron density maps; the program XPLOR was also used
30 for calculation of the maps which were displayed on a
Silicon Graphics terminal using the program O (Jones,
T.A., Zou, J.Y., Cowan, S.W. and Kjeldgaard, M. (1991).
"Improved methods for binding protein models in electron

density maps and the location of errors in these models," *Acta Crystallogr.* **A47**, 110-119).

New electron density at the expected active site could in all cases be interpreted with flexible, three-dimensional models of the inhibitors as generated in the program INSIGHTII (Biosym Technologies (1993). Insight II User Guide, Version 2.2.0. San Diego). Solvent positions were also identified from these electron density maps and side chains of the protein were also sometimes manually adjusted.

Final refinements of the structure were carried out with inclusion of inhibitor and solvent ligands. In the refinements, 10% of the data was set aside for cross validation by evaluation of R_{free} (A.T. Brünger, "Free R Value: a novel statistical quantity for accessing the accuracy of crystal structures," *Nature* **355**, 472-475 (1992)). Results are shown in the Table IV.

Table IV.

Compound with which MMP-8 catalytic domain (residues 85-242) is complexed ^a	Resolution ^j	$R_{\text{free}}/R_{\text{work}}^k$	Reflection ^m	rms Bond ⁿ	rms Angle ^p
XII	8.00-1.65	0.249(0.290) / 0.187(0.284)	17419	0.01	1.6
IX	8.00-1.64	0.286(0.370) / 0.188(0.323)	15052	0.01	1.7
X	8.00-1.69	0.276(0.283) / 0.195(0.271)	14239	0.02	2.0
XI	8.00-1.83	0.262(0.376) / 0.168(0.225)	12019	0.02	1.9
XIV	8.00-1.46	0.222(0.215) / 0.181(0.215)	26180	0.01	1.7
XV	8.00-1.43	0.208(0.232) / 0.174(0.247)	26617	0.01	1.7

^aInhibitor code.

^jresolution (in angstroms).

^knumber of reflections.

^mR_{work}/R_{free} for overall and highest resolution shell

5 ⁿRMS deviation in bond lengths (in angstroms).

^pRMS deviation in covalent bond angles (in degrees).

10 In the case of Formula XIII, we noticed that the refinement yielded an unexpected conformation for the side chain of Arg 222. Display of the electron density maps verified the new position for this residue. Analysis of the structure also revealed that retention of the previously observed conformation of this residue
15 would have led to steric clash with the P1' moiety of the inhibitor.

In the cases of Formulas IX, X and XI, the refinement yielded a completely new position for Tyr 227 in addition to the perturbed Arg 222 side chain. The
20 new Tyr position was resulted from a major movement backbone and sidechains for residues 224-229. Display of the electron density maps verified the new position for this residue. Analysis of the structure also revealed that retention of the previously observed
25 conformations of this residues would have led to steric clash between the side chain of Tyr 227 and the P1' moiety of the inhibitor.

The combination of the swerve of Arg 222 side chain and the conformation changes in residues 224-229
30 essentially opens up the enzyme S1' pocket. In this new form, inhibitors with longer (equivalent to seven and more carbon chains beyond the second ring) and bigger P1' (-CF₃, -(C₆H₄)-, etc.) moieties can be accommodated. Two factors govern the inhibitor P1' moiety: it has to
35 be nonpolar (a single polar -NH₂ group has been shown tolerable) to pass through the highly hydrophobic S1'

pocket of the enzyme and it has to have some exposed polar groups when the chain is long enough to protrude itself out to the hydrophilic solvent region.

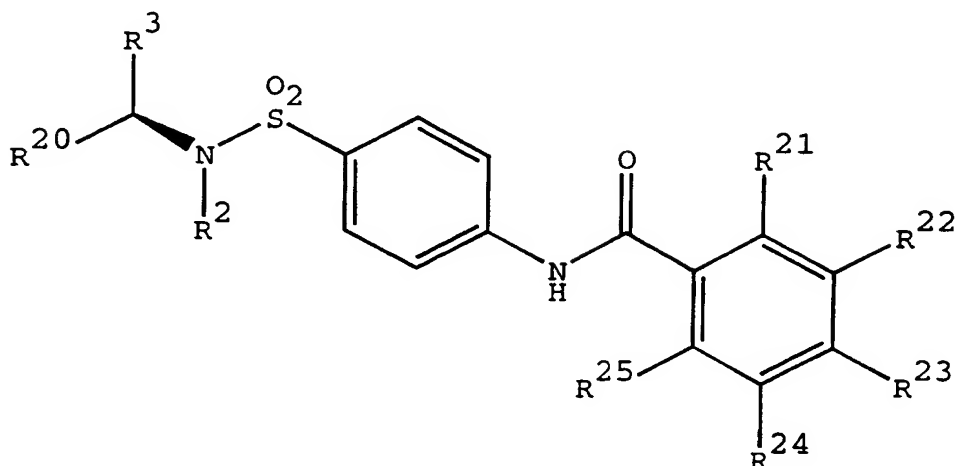
5 The examples herein can be performed by substituting the generically or specifically described reactants and/or operating conditions of this invention for those used in the preceding examples.

10 The invention being thus described, it is apparent that the same can be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the present invention, and all such modifications and equivalents as would be obvious to one skilled in the art are intended to be included
15 within the scope of the following claims.

CLAIMS

What is claimed is:

1. A matrix metalloproteinase inhibiting compound
5 having the structure:



10 or a salt, an enantiomer, a diastereomer, a
racemate, or a tautomer thereof, wherein:

R^2 is selected from the group consisting of H,
alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl,
alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl,
15 aminoalkyl, alkylaminoalkyl, heterocycloalkyl,
and heterocycloalkylalkyl;

R^3 is selected from the group consisting of H,
alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl,
alkylaryl, arylalkyl, alkoxy, alkoxyalkyl,
hydroxyalkyl, aminoalkyl, alkylaminoalkyl,
20 haloalkoxy, haloalkylthio, and heterocycloalkyl;

R^{20} is selected from the group consisting of
-C(O)OH, -C(O)NHOH, -SH, and -C(O)SH; and

R^{21} , R^{22} , R^{23} , R^{24} , and R^{25} are independently
selected from the group consisting of H, C_1 to
25 about C_{20} alkyl, C_1 to about C_{20} alkenyl, C_1 to
about C_{20} alkynyl, cycloalkyl, haloalkyl,
alkoxyalkyl, hydroxyalkyl, aminoalkyl,

alkylaminoalkyl, nitroalkyl, heterocycloalkyl,
alkoxy, cycloalkoxy, alkoxy carbonyl,
alkoxyalkyl, haloalkoxy, haloalkylthio,
alkylamino, and carboxyalkyl.

5

2. The matrix metalloproteinase inhibiting compound
of claim 1 wherein R^{20} is selected from the group
consisting of $-C(O)OH$ and $-C(O)NHOH$.

10 3. The matrix metalloproteinase inhibiting compound
of claim 2 wherein R^{21} and R^{25} are H.

4. The matrix metalloproteinase inhibiting compound
of claim 3 wherein R^{22} and R^{24} are H.

15

5. The matrix metalloproteinase inhibiting compound
of claim 4 wherein R^{23} is C_1 to about C_{20} alkyl.

20 6. The matrix metalloproteinase inhibiting compound
of claim 5 wherein R^{23} is C_1 to about C_{20} linear
alkyl.

7. The matrix metalloproteinase inhibiting compound
of claim 2 wherein R^{20} is $-C(O)OH$.

25

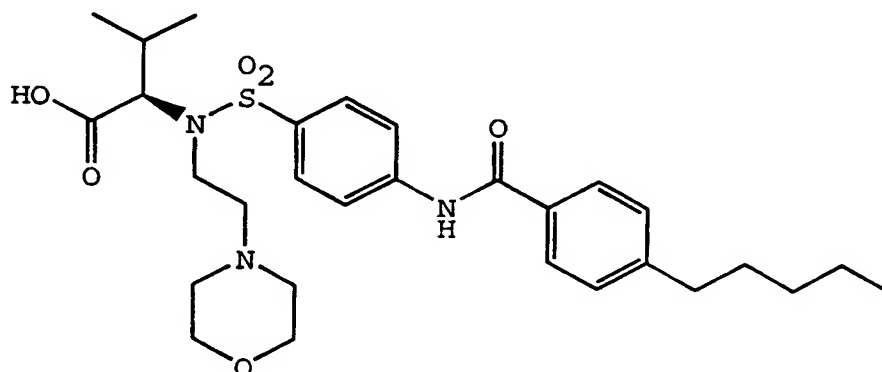
8. The matrix metalloproteinase inhibiting compound
of claim 7 wherein R^3 is selected from the group
consisting of alkyl, alkenyl, alkynyl,
haloalkoxy, haloalkylthio, and heterocycloalkyl.

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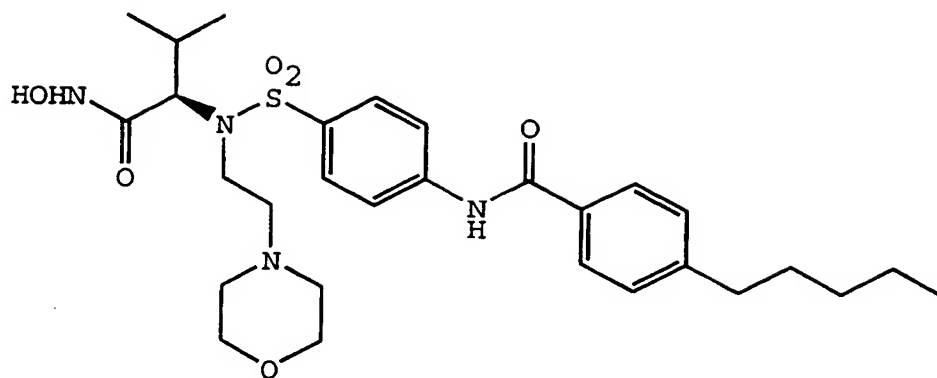
9. The matrix metalloproteinase inhibiting compound
of claim 8 wherein R^3 is heterocycloalkyl.

35 10. The matrix metalloproteinase inhibiting compound
of claim 9 wherein R^3 is 2-(N-morpholino)ethyl.

11. The matrix metalloproteinase inhibiting compound of claim 2 wherein R^{20} is $-C(O)NHOH$.
12. The matrix metalloproteinase inhibiting compound of claim 11 wherein R^3 is selected from the group consisting of alkyl, alkenyl, alkynyl, haloalkoxy, haloalkylthio, and heterocycloalkyl.
13. The matrix metalloproteinase inhibiting compound of claim 12 wherein R^3 is heterocycloalkyl.
14. The matrix metalloproteinase inhibiting compound of claim 13 wherein R^3 is 2-(N-morpholino)ethyl.
15. The matrix metalloproteinase inhibiting compound of claim 14 having the structure



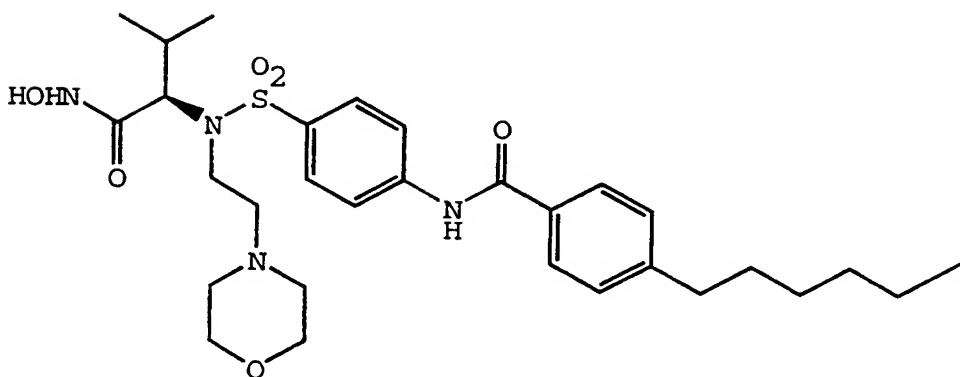
- or a salt, an enantiomer, a racemate, or a tautomer thereof.
16. The matrix metalloproteinase inhibiting compound of claim 14 having the structure



or a salt, an enantiomer, a racemate, or a
tautomer thereof.

5

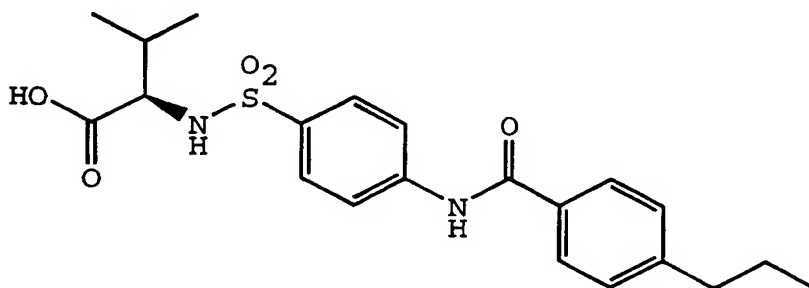
17. The matrix metalloproteinase inhibiting compound
of claim 14 having the structure



10

or a salt, an enantiomer, a racemate, or a
tautomer thereof.

18. The matrix metalloproteinase inhibiting compound of claim 14 having the structure

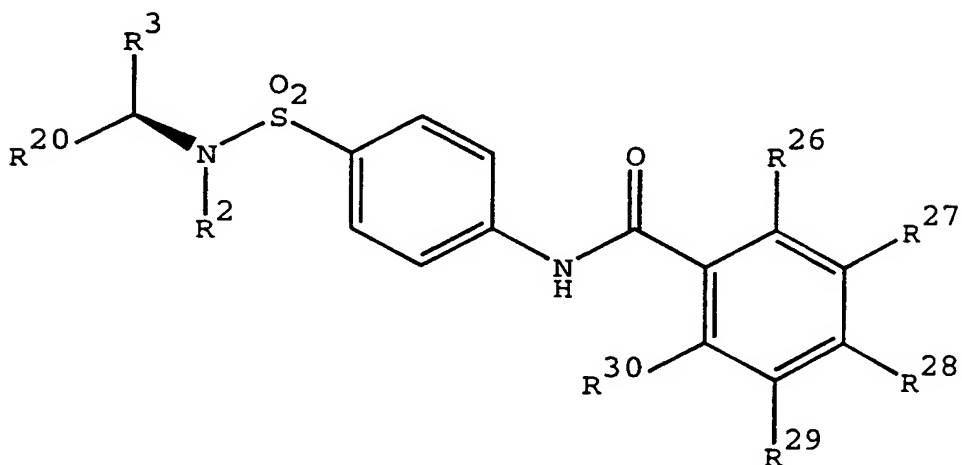


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or a salt, an enantiomer, a racemate, or a tautomer thereof.

19. A method of changing the conformation of a matrix metalloproteinase wherein the method comprises contacting the matrix metalloproteinase with a compound having the formula:

10



15

or a salt, an enantiomer, a diastereomer, a racemate, or a tautomer thereof, thereby changing the conformation of the matrix metalloproteinase, wherein:

20

R^2 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl,

alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, heterocycloalkyl, and heterocycloalkylalkyl;

5 R^3 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxy, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, haloalkoxy, haloalkylthio, and heterocycloalkyl;

10 R^{20} is selected from the group consisting of -C(O)OH, -C(O)NHOH, -SH, and -C(O)SH; and

R^{26} , R^{27} , R^{28} , R^{29} , and R^{30} are independently selected from the group consisting of about C_3 to about C_{20} alkyl, about C_3 to about C_{20} alkenyl, about C_3 to about C_{20} alkynyl, cycloalkyl, 15 haloalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, nitroalkyl, heterocycloalkyl, alkoxy, cycloalkoxy, alkoxycarbonyl, alkoxyalkyl, haloalkoxy, haloalkylthio, alkylamino, and carboxyalkyl.

20

20. The method of claim 19 wherein R^{20} is selected from the group consisting of -C(O)OH and -C(O)NHOH.

25 21. The method of claim 19 wherein R^3 is selected from the group consisting of H, alkyl, alkenyl, alkynyl, haloalkoxy, haloalkylthio, and heterocycloalkyl

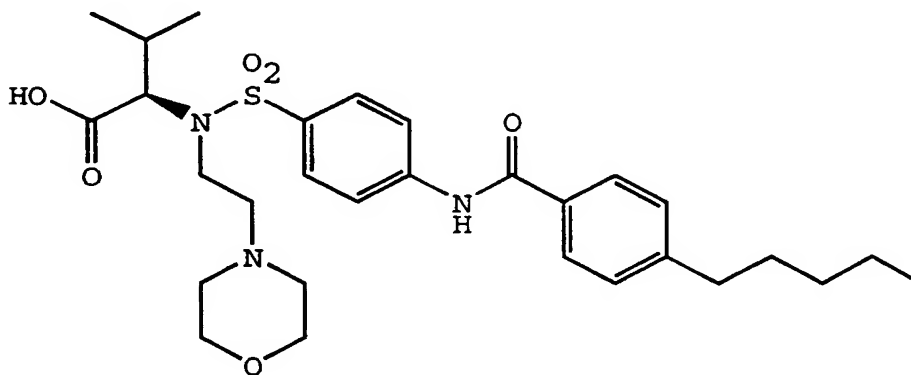
30 22. The method of claim 21 wherein R^3 is a C_1 to about C_{12} alkyl.

23. The method of claim 22 wherein R^3 is a C_1 to about C_4 alkyl.

35

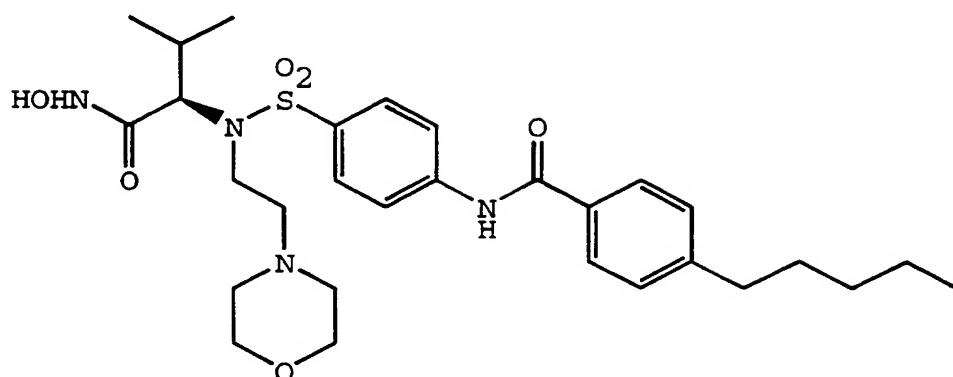
24. The method of claim 23 wherein R^3 is isopropyl.

25. The method of claim 19 wherein R^2 is heterocycloalkylalkyl.
- 5 26. The method of claim 25 wherein R^2 is 2-(N-morpholino)ethyl.
27. The method of claim 19 wherein R^{26} and R^{30} are H.
- 10 28. The method of claim 27 wherein R^{27} and R^{29} are H.
29. The method of claim 28 wherein R^{28} is about C_3 to about C_{20} alkyl.
- 15 30. The method of claim 29 wherein R^{28} is about C_3 to about C_{20} linear alkyl.
31. The method of claim 30 wherein R^{28} is selected from the group consisting of n-propyl, n-butyl, 20 n-pentyl and n-hexyl.
32. The method of claim 31 wherein the compound has the structure:



or a salt, an enantiomer, a racemate, or a tautomer thereof.

33. The method of claim 31 wherein the compound has the structure:

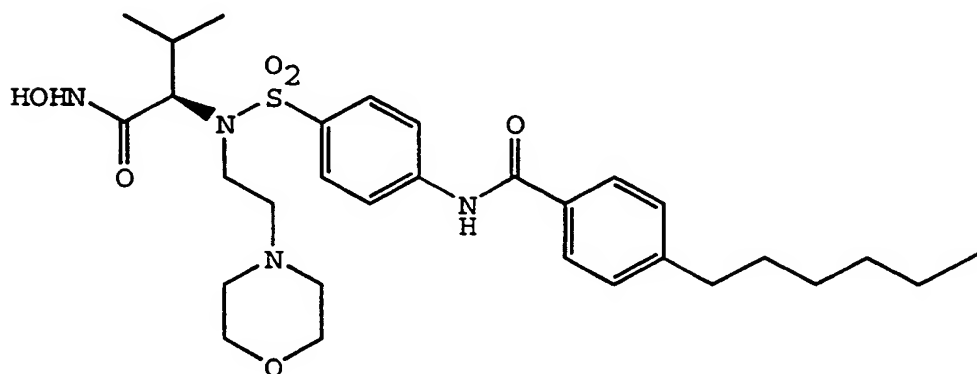


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or a salt, an enantiomer, a racemate, or a tautomer thereof.

34. The method of claim 31 wherein the compound has the structure:

10

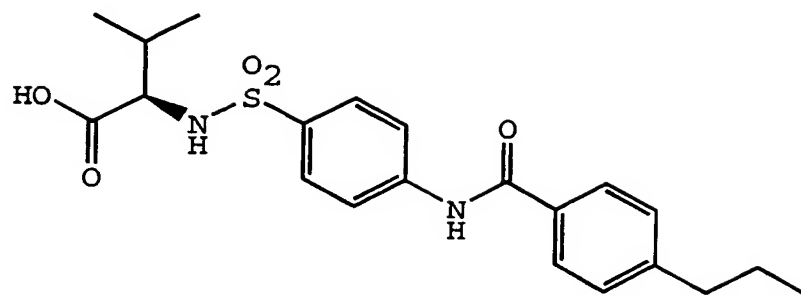


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or a salt, an enantiomer, a racemate, or a tautomer thereof.

35. The method of claim 31 wherein the compound has the structure:

20



or a salt, an enantiomer, a racemate, or a tautomer thereof.

5

36. The method of claim 19 wherein the matrix metalloproteinase is selected from the group consisting of MMP-8 and MMP-13.

10

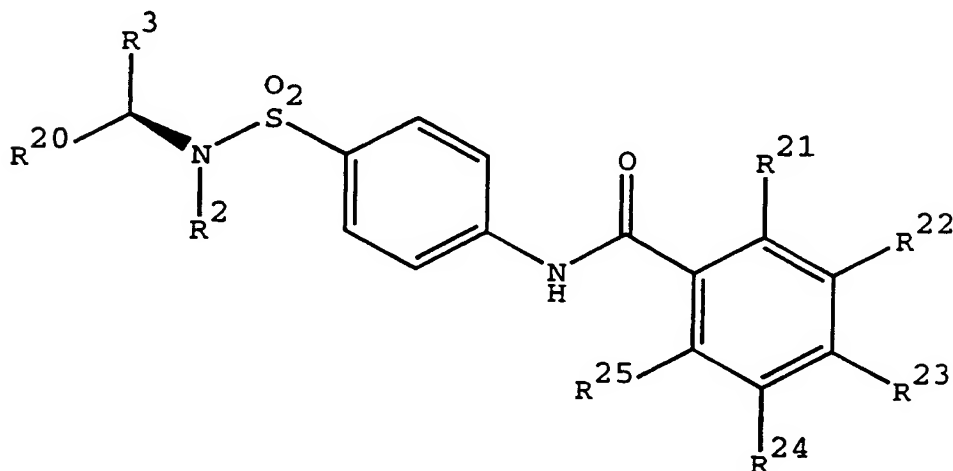
37. The method of claim 36 wherein the matrix metalloproteinase is MMP-8.

38. The method of claim 36 wherein the matrix metalloproteinase is MMP-13.

15

39. A method of inhibiting a matrix metalloproteinase wherein the method comprises contacting the matrix metalloproteinase with a compound having the formula:

20



or a salt, an enantiomer, a diastereomer, a
racemate, or a tautomer thereof, thereby
inhibiting the matrix metalloproteinase,
wherein:

R^2 is selected from the group consisting of H,
alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl,
alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl,
aminoalkyl, alkylaminoalkyl, heterocycloalkyl,
and heterocycloalkylalkyl;

R^3 is selected from the group consisting of H,
alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl,
alkylaryl, arylalkyl, alkoxy, alkoxyalkyl,
hydroxyalkyl, aminoalkyl, alkylaminoalkyl,
haloalkoxy, haloalkylthio, and heterocycloalkyl;

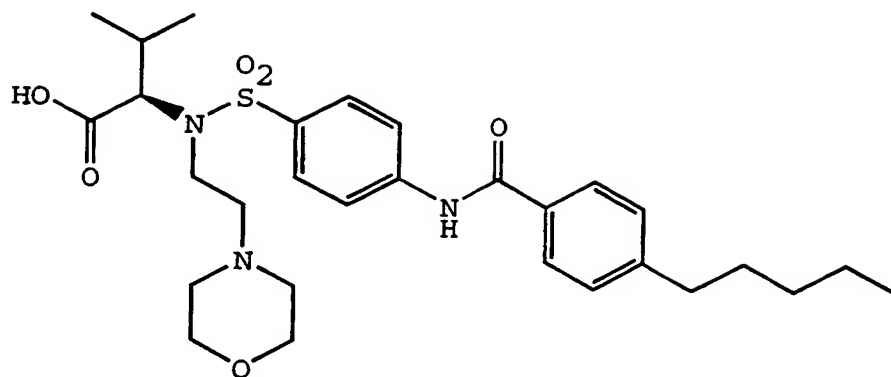
R^{20} is selected from the group consisting of
-C(O)OH, -C(O)NHOH, -SH, and -C(O)SH; and

R^{21} , R^{22} , R^{23} , R^{24} , and R^{25} are independently
selected from the group consisting of H, C_1 to
about C_{20} alkyl, C_1 to about C_{20} alkenyl, C_1 to
about C_{20} alkynyl, cycloalkyl, haloalkyl,
alkoxyalkyl, hydroxyalkyl, aminoalkyl,
alkylaminoalkyl, nitroalkyl, heterocycloalkyl,
alkoxy, cycloalkoxy, alkoxycarbonyl,
alkoxyalkyl, haloalkoxy, haloalkylthio,
alkylamino, and carboxyalkyl.

40. The method of claim 39 wherein R^{20} is selected
from the group consisting of -C(O)OH and
-C(O)NHOH.

41. The method of claim 39 wherein R^3 is selected
from the group consisting of H, alkyl, alkenyl,
alkynyl, haloalkoxy, haloalkylthio, and
heterocycloalkyl.

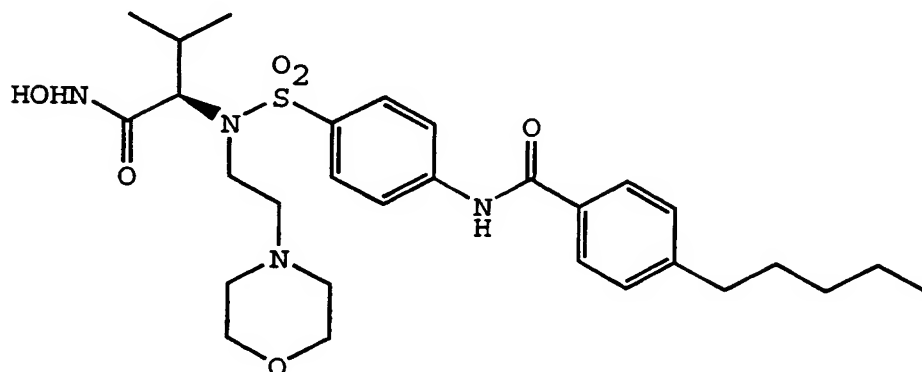
42. The method of claim 41 wherein R^3 is a C_1 to about C_{12} alkyl.
- 5 43. The method of claim 42 wherein R^3 is a C_1 to about C_4 alkyl.
44. The method of claim 43 wherein R^3 is isopropyl.
- 10 45. The method of claim 39 wherein R^2 is heterocycloalkylalkyl.
46. The method of claim 45 wherein R^2 is 2-(N-morpholino)ethyl.
- 15 47. The method of claim 39 wherein R^{21} and R^{25} are H.
48. The method of claim 47 wherein R^{22} and R^{24} are H.
- 20 49. The method of claim 48 wherein R^{23} is C_1 to about C_{20} alkyl.
50. The method of claim 49 wherein R^{23} is methyl or C_2 to about C_{20} linear alkyl.
- 25 51. The method of claim 50 wherein R^{23} is n-pentyl or n-hexyl.
- 30 52. The method of claim 51 wherein the compound has the structure:



or a salt, an enantiomer, a racemate, or a tautomer thereof.

5

53. The method of claim 51 wherein the compound has the structure:

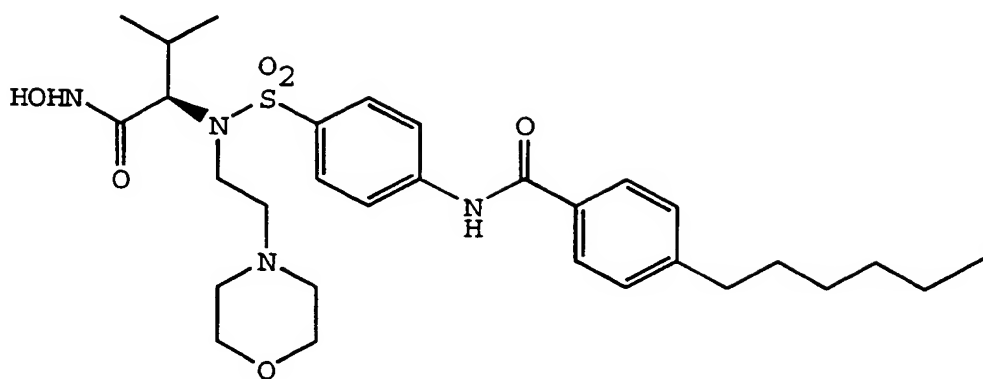


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or a salt, an enantiomer, a racemate, or a tautomer thereof.

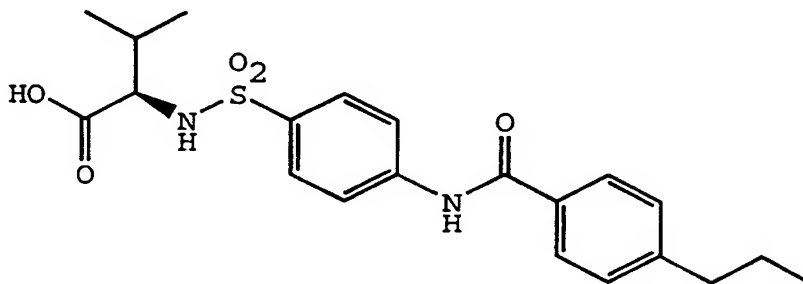
54. The method of claim 51 wherein the compound has the structure:

15



or a salt, an enantiomer, a racemate, or a
tautomer thereof.

55. The method of claim 51 wherein the compound has the structure:

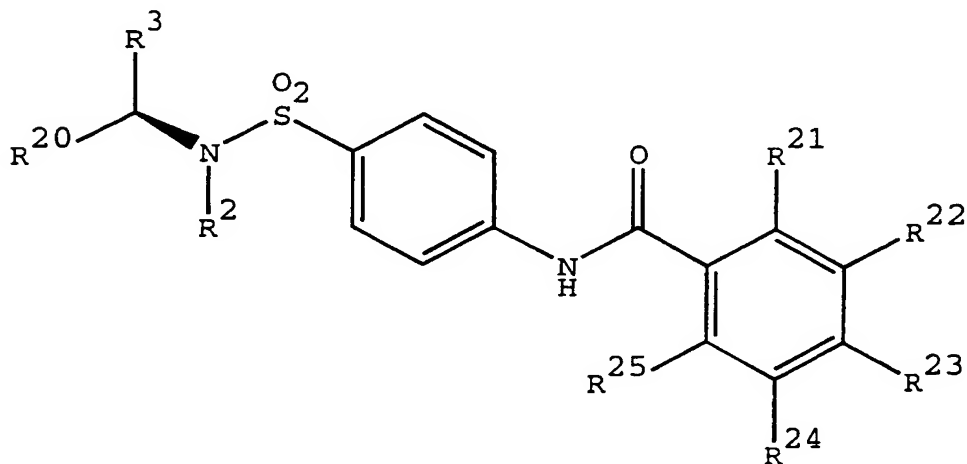


or a salt, an enantiomer, a racemate, or a
tautomer thereof.

56. The method of claim 39 wherein the matrix metalloproteinase is selected from the group consisting of MMP-8 and MMP-13.
57. The method of claim 56 wherein the matrix metalloproteinase is MMP-8.
58. The method of claim 56 wherein the matrix metalloproteinase is MMP-13.

59. A method treating osteoarthritis in a mammal wherein the method comprises providing to the mammal an osteoarthritis-treating-effective amount of a compound having the formula:

5



or an enantiomer, diastereomer, racemate, or tautomer thereof, thereby treating osteoarthritis, wherein:

10

R² is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, heterocycloalkyl, and heterocycloalkylalkyl;

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R³ is selected from the group consisting of H, alkyl, alkenyl, alkynyl, cycloalkyl, haloalkyl, alkylaryl, arylalkyl, alkoxy, alkoxyalkyl, hydroxyalkyl, aminoalkyl, alkylaminoalkyl, haloalkoxy, haloalkylthio, and heterocycloalkyl;

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R²⁰ is selected from the group consisting of -C(O)OH, -C(O)NHOH, -SH, and -C(O)SH; and

R²¹, R²², R²³, R²⁴, and R²⁵ are independently selected from the group consisting of H, C₁ to about C₂₀ alkyl, C₁ to about C₂₀ alkenyl, C₁ to about C₂₀ alkynyl, cycloalkyl, haloalkyl, alkoxyalkyl, hydroxyalkyl, aminoalkyl,

25

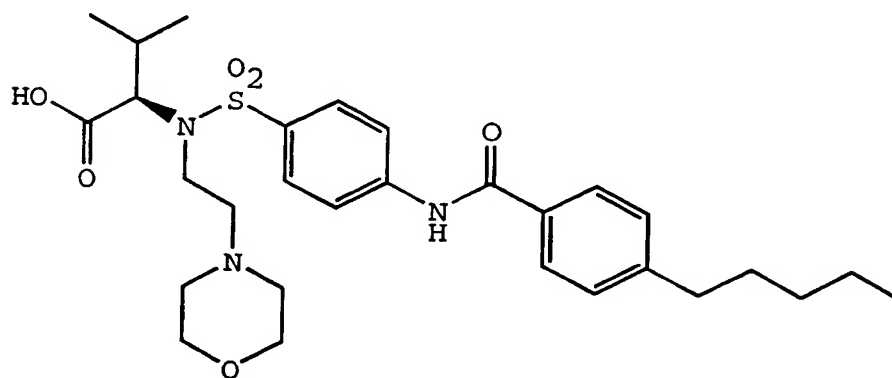
alkylaminoalkyl, nitroalkyl, heterocycloalkyl,
alkoxy, cycloalkoxy, alkoxy carbonyl,
alkoxyalkyl, haloalkoxy, haloalkylthio,
alkylamino, and carboxyalkyl.

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60. The method of claim 59 wherein the mammal is a
human.

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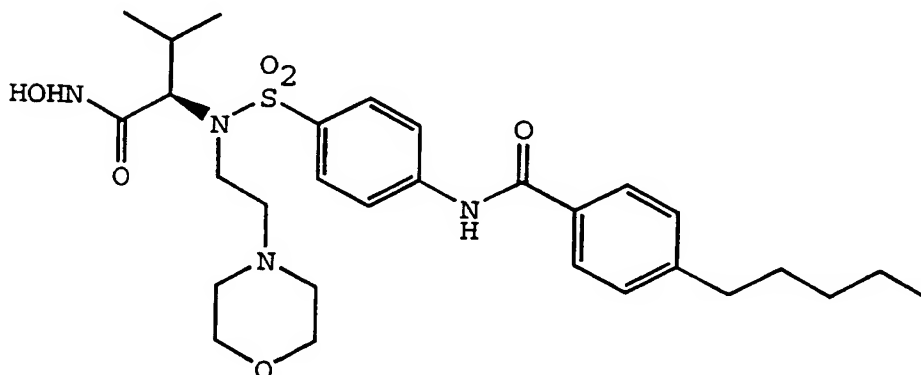
61. The method of claim 60 wherein the compound has
the structure:



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or a salt, an enantiomer, a racemate, or a
tautomer thereof.

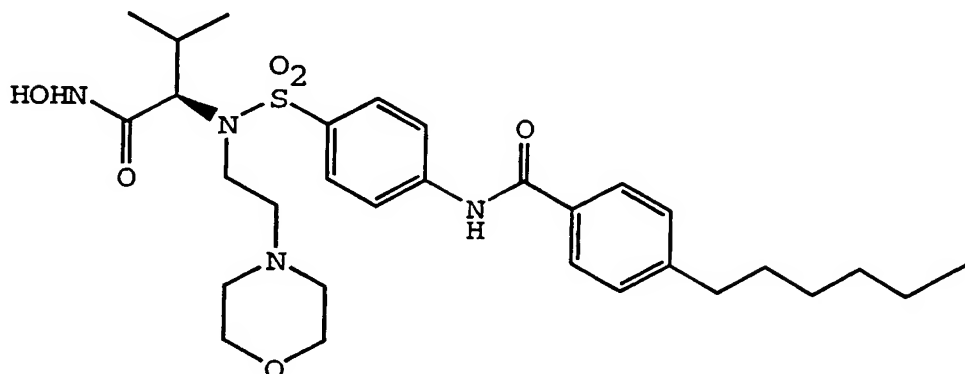
62. The method of claim 60 wherein the compound has
the structure:



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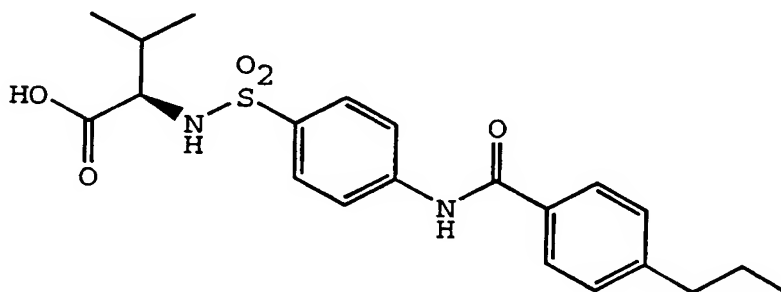
or a salt, an enantiomer, a racemate, or a tautomer thereof.

63. The method of claim 60 wherein the compound has the structure:



- or a salt, an enantiomer, a racemate, or a tautomer thereof.

64. The method of claim 60 wherein the compound has the structure:



or a salt, an enantiomer, a racemate, or a tautomer thereof.